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Volume 21, Number 5

Use Factors in Machine Value

CUSTOMER satisfaction with farm operating equipment, and inclination and financial ability to buy more equipment, depends not only on its mechanical serviceability, but on its contribution to the farmer's overall efficiency and earning power. Manufacturers already provide mechanical data on their equipment, as to its capacity, care, adjustment, and in some cases operating methods, to help farmers get the satisfactory mechanical performance it can give. Enough farmers follow enough of the suggestions to justify the manufacturers in putting out this information, and farmers are continually becoming more machine-minded. As a logical further step to promote customer satisfaction, it seems possible that manufacturers may soon find it to their advantage to take the initiative in developing and publishing economic application data on their various models and equipment combinations. This would help farmers to see the influence of extent of use, methods, conditions, and labor efficiency on the financial satisfaction to be gained from use of the equipment. It would relate machine use and investment to other factors in cost of production, and would be a real contribution to progress in farm operating efficiency and farm prosperity, through application of principles of production engineering.

AGRICULTURAL ENGINEERING

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Farm Operating Efficiency

IS or is not farm operating efficiency an important factor in farm progress? Strong proponents of both sides of the question make it an issue. The individual farmer can take it or leave it, but for the public service agencies of agriculture, for the industries supplying farmers with production goods, and for agricultural engineers, it is a matter of principle affecting their policies of service to farmers. So long as there is an outside chance that it may be important, it cannot be ignored in any policy relating to agricultural progress, except a policy of drifting. And if it is important, enough has already been done to show that the subject might be dealt with far more thoroughly, scientifically, and effectively than it has, up to the present.

Jumping over philosophical and social questions as to the ultimate influences of prosperity, and the social morality or ethics of utilization of human and natural resources, we might develop the subject briefly from this point: Right or wrong, farmers individually and collectively, and society as represented in the federal and state governments, are definitely committed to increasing farm prosperity in one way or another. The people to be served believe it would be desirable and important to farm progress. But increased farm operating efficiency has not yet been generally accepted as the best way, or even an important way to increase farm prosperity.

In fundamental terms, there are only two ways of increasing the material prosperity of any individual or group. One is to give that individual or group material values created by others. The other way is for the individual or group in question to create more material values.

If we can consider that any competent, able-bodied, and self-respecting man wants to be self-supporting, the question of increasing farm prosperity becomes a question of devising ways and means by which he can render a larger measure of economic service.

A farmer can render a larger measure of economic service, in other words, produce more values, either by working more hours per year, or by working more effectively, so that each hour of his work produces more net value.

Most farmers work the limit of hours during planting and harvest time, or all through the growing season. Livestock farmers probably work more hours per year than most people in urban industries. In some cases farmers have a slack winter season during which they have available work hours which could be used to increase their income if they could find opportunity to use this time creatively either on or off the farm. However, these opportunities are limited and do not apply to the majority of farmers who are already making farming a full-time job.

Of the possible ways in which a farmer can increase the effectiveness of his work, one is by making farming a secondary or part-time occupation, and finding employment in industries already organized to make highly effective use of his time and abilities. These opportunities are also limited, especially in times of high urban unemployment.

Eliminating direct subsidy or charity, as unsatisfactory ways of improving farm prosperity, and accepting increased work time and work elsewhere than on the farm as possibilities of comparatively minor importance, it seems that if there is any prospect of materially increasing farm prosperity, as generally desired, it is in the direction of improving farm operating efficiency.

But does improvement of farm operating efficiency offer much reasonable hope for increasing farm prosperity to any important extent? Is there much room for improvement? Considering the improvement that has been made in the past century, the progress that has been made in other industries, and the progress that is continually being made by a comparatively small number of the most progressive farmers, we believe there is extensive room for improvement in farm operating efficiency.

And if farm operating efficiency is improved to any important extent, will it give increased prosperity or will it likely be neutralized by increased competition? Competition will increase as apparent opportunity for prosperity is added to the security and living advantages of farming. It will be one influence on the supply and demand relationships which determine the economic value represented per unit of commodity produced.

But improved farm operating efficiency will also provide opportunity for a satisfactory margin of farm profit at lower commodity prices, which will encourage the use of a larger quantity of farm products. These lower commodity prices will also encourage the development of new uses and new volume demand for farm products. Population increase is still another factor adding to the total economic service that can be rendered by farmers. Lower production costs would improve the American farmers' position to compete in both domestic and world markets, to render a larger share of the total economic service produced by all farmers of the world.

Improvement in farm operating efficiency cannot be uniform. There will still be a survival of the fittest. But farm operating efficiency and total economic service produced by farmers can be increased more rapidly than the number of farmers who contribute to it, and among whom its returns are divided. This means increased average and total farm prosperity.

If the importance of farm operating efficiency can be accepted on this basis, what are its implications affecting policies of service to agriculture?

From the standpoint of the public service agencies of agriculture, it suggests increased attention to analysis, interpretation, and correlation of the information produced by the specialized sciences with a specific view to its possible application to improve farm operating efficiency. It suggests research along lines which offer reasonable hope of providing new information which would prove valuable in improving farm operating efficiency. It suggests teaching in the agricultural colleges, schools of vocational agriculture, and agricultural extension services, of production principles and practices from the standpoint of their influence on farm operating efficiency. It suggests abandoning activities designed to improve farm prosperity in ways which may be less promising and not worth the cost.

From the standpoint of industries providing farmers with production goods, it suggests that customer satisfaction and future purchases are influenced not only by quality of materials and mechanical serviceability, but by the use of such goods in ways that make a worth-while contribution to farm operating efficiency. Any help that manufacturers may be able to give farmers as to the effective use of their

production goods might prove a profitable service, from the manufacturers' standpoint as well as for farmers.

. From the standpoint of agricultural engineers, it suggests that they take an active interest in, explain, promote, and encourage the cooperation of others in work toward improved farm operating efficiency. It suggests giving increased attention to the production engineering aspects of agricultural engineering. If engineering implies effective use of human and natural resources, agricultural engineers might well take the initiative in the important job of encouraging their more effective use in agriculture.

Annual Meeting Emphasis

WE SEE in the program for the annual meeting of the American Society of Agricultural Engineers at Pennsylvania State College, June 17-20, a growing emphasis on appraisal of agricultural engineering functions, on mastery of the basic science involved in agricultural engineering problems, and on keeping fully up to date on progress in this and related fields.

Pressure to make technical progress count for more, and more visible, human progress, pushes agricultural engineers not only to more and better work, but toward a better understanding of how they may best serve agriculture, and to clearer explanations to themselves and others, of their opportunities for service and of the influences of their work.

The whole history of progress in agriculture has been a record of replacing custom, superstition, and assumption with scientific knowledge, as a basis for action calculated to achieve desired results. Each advance in agricultural and engineering science suggests reconsideration of agricultural engineering problems from the standpoint of what is known, what must be assumed, and what remaining assumptions might be eliminated by further scientific progress.

This pressure for practical results and the rate of progress in science and its applications puts a premium on knowledge of what is going on in various fields of scientific, commercial, and agricultural development and practice. New approaches to problems, new contacts, new data, new ideas, new inspiration, and new viewpoints are the nourishment of individual progress.

This year's annual meeting program of the American Society of Agricultural Engineers gives promise of meeting these needs more fully than ever, for agricultural engineers as a group, and particularly for those who can attend.

Nut Cracker Stars in Movies

ACCORDING to word received from the division of agricultural engineering, University of California, its internal-combustion nut cracker has recently been a star performer before newsreel cameras.

Most of the value in agricultural engineering work depends on influences more enduring and far reaching than transient satisfaction of public interest in the spectacular. There are, however, these occasional developments which incidentally embody the essentials of popular interest, and which, with good showmanship, can be used to let more people know that there are agricultural engineers in this world, that agricultural engineers are helping to solve some farm problems, and that their work also helps manufacturers, processors, and consumers.

We only hope that in presenting the nut cracker to the world, the newsreels may emphasize, not the temporary labor displacement its use may involve, but the larger industry, the increased total employment, and the larger five-cent bag of nut meats which may result.

A New Drying Agent

ONE of the limiting factors in the artificial drying of farm products, particularly grain and other seeds, by heated air is the well-known "casehardening" effect, or tendency of the outside layer to dry first and to become relatively impervious to the outward passage of moisture from inside the grain or other product unit.

Some years ago W. M. Hurst and W. R. Humphries reported briefly[1] on experiments in which a silica drying agent was mixed with grain. Satisfactory drying of small samples was accomplished, but the process involved mixing a considerable amount of the dryer with the grain, allowing time for absorption of moisture, separating the dryer from the grain, and dehydrating it for reuse. Apparently the economics of the operation were not promising, as we have heard little more of studies along this line. A recent announcement of an application of another chemical dryer in the air and kiln-drying of lumber[2], however, suggests consideration and investigation of its possibilities for some farm product drying jobs. Could it be used to advantage in drying grain, other seed crops, forage or fibers, tubers, root crops, fruit, or nuts?

Synthetic crystalline urea is the chemical in question. It is reported to be non-corrosive, harmless to the human skin, and to have a moderately toxic effect on fungi. It is chemically stable and does not discolor wood. Apparently it is somewhat deliquescent, judging from the report that when it is applied to green wood, the wood dries from the inside out, the outside remaining moist during the process and drying last. This characteristic would be desirable in farm product drying to avoid the casehardening effect.

Since the chemical is cheap enough to be used in fertilizer manufacture, it might prove an economical drying agent without recovery and reuse. Whether or not it could be left on the grain or other product would depend on its effect on use value. Would the urea cause excessive drying of the product? After it had dried the product and was dried in turn by heated air, would it reabsorb moisture from the air? If not, there might be a positive advantage in leaving it on seeds for planting, from the standpoint of its fertilizer, fungicidal, and possible insecticidal values.

It is also possible that presence of this chemical, at least in the small amounts which would be most difficult to remove, might not reduce the value of materials for livestock feeds, industrial processing, or even for human food.

Or where the presence of the chemical would reduce use value of the dried commodity, could it be separated in the course of regular milling or processing operations? If not, how tightly would it adhere to the surface of the dried commodity? Could it be separated by rubbing or brushing and blowing, or other dry-cleaning processes? Would it dry the product so thoroughly that it could be washed off and leave the commodity with only a minor surface-drying problem?

Might this chemical be useful for the quick drying and preservation for year-round industrial processing of such crops as Jerusalem artichokes, the high perishability of which is a limiting factor in present production and use?

Such are the questions, possibilities, and hopes raised by the discovery of one new use for a well-known chemical. The problem of drying various farm products is of major importance and suggests the desirability of thoroughly investigating the possibilities of urea as a drying agent.

[1]An absorptive agent for drying grain, by W. M. Hurst and W. R. Humphries. AGRICULTURAL ENGINEERING, 17:62, February 1936.

[2]Du Pont Agricultural News Letter, March-April 1940.

Mounted Plows and Their Effects on the Tractor

By A. W. Clyde
FELLOW A.S.A.E.

PLOWS and certain other tillage tools mounted on the tractor have been made to a limited extent for many years. During the past year, however, mounted or unit plows in the one and two-bottom sizes have become considerably more popular. A mounted plow has some advantages over the conventional separate plow. One advantage is that it usually can be sold at a lower price because of lighter weight and perhaps fewer parts. Another is that it can be maneuvered more easily close to fences and into corners. Its depth and width control may or may not be better, depending largely on the individual design. The most evident drawbacks of mounted plows are that they are not as quickly detachable as the separate type, and that adequate overload protection is not as easy to provide. Whether these points are of much importance depends on the conditions of use.

In addition to the above, there are several features of mounted plows, which, although not as evident, are important because they influence the horizontal hitch and probably the steering control of the tractor, or the vertical hitch with a consequent effect on drivewheel loading and traction. Possible horizontal and vertical effects will be discussed in turn.

Horizontal Effects. The horizontal hitch deserves some consideration when the plow is much narrower than the tractor, as in Fig. 1. The usual location of a separate plow is shown at *a* and at *b* the location of a typical mounted plow. The location of force intersection, *H,* through which the pulling force must pass, together with the position of the pulling force relative to *CP,* has been discussed in

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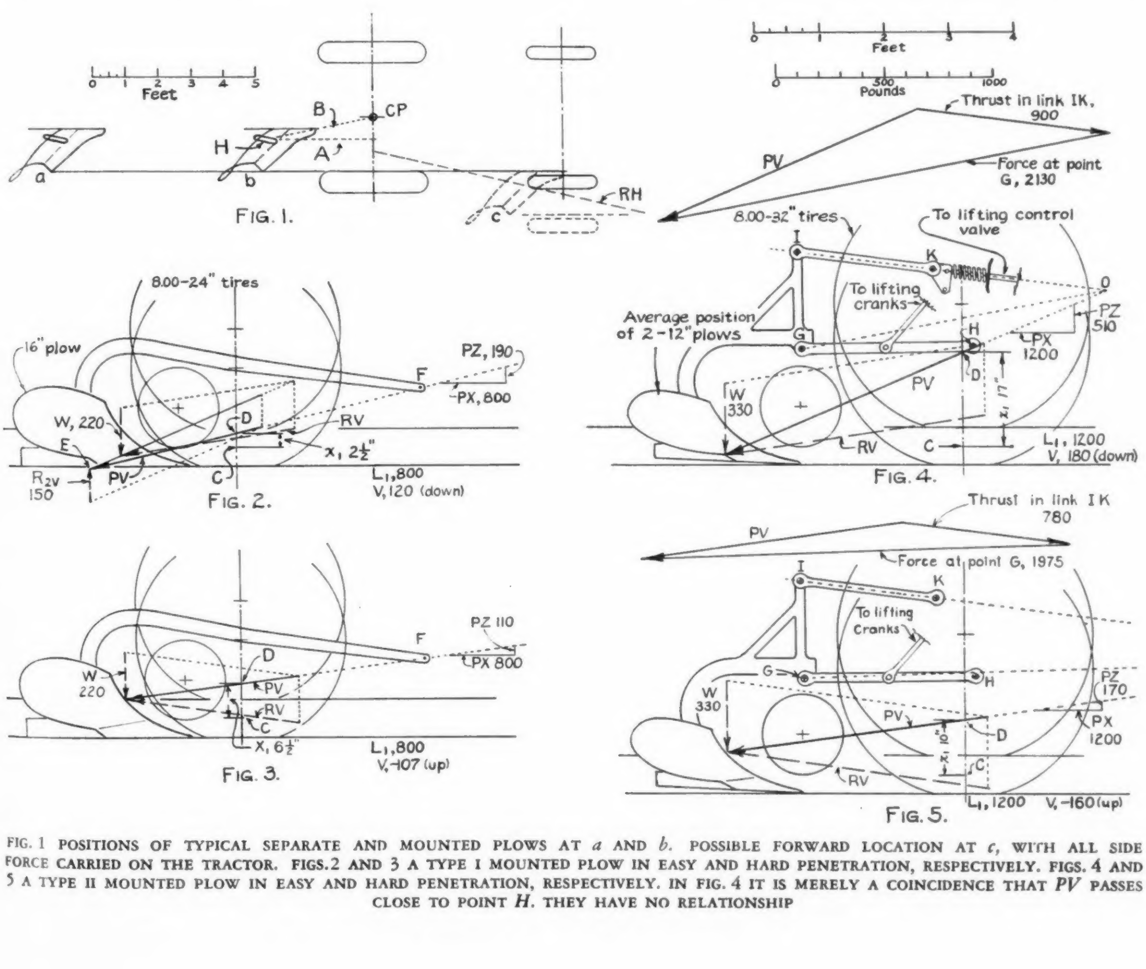

FIG. 1 POSITIONS OF TYPICAL SEPARATE AND MOUNTED PLOWS AT *a* AND *b*. POSSIBLE FORWARD LOCATION AT *c*, WITH ALL SIDE FORCE CARRIED ON THE TRACTOR. FIGS. 2 AND 3 A TYPE I MOUNTED PLOW IN EASY AND HARD PENETRATION, RESPECTIVELY. FIGS. 4 AND 5 A TYPE II MOUNTED PLOW IN EASY AND HARD PENETRATION, RESPECTIVELY. IN FIG. 4 IT IS MERELY A COINCIDENCE THAT *PV* PASSES CLOSE TO POINT *H*. THEY HAVE NO RELATIONSHIP

previous reports[1 and 2]. It is evident that position *b* is less favorable than *a*. If the pulling force is in the direction of travel as shown by *A*, there is the same offset hitch on the tractor in either case. If, however, the pull is at *B*, or between *A* and *B* to facilitate steering, then the angle of pull on the plow is worse for the mounted plow.

It has been suggested that the plow might be moved ahead somewhere near *c* and that all side force be carried on the tractor rear wheels. *RH* shows the typical direction of force on the tractor in this case. It is considerably offset from *CP*, which is undesirable. As will be seen later, this position of the plow is also unfavorable from a traction standpoint. It appears, therefore, that the forward position, such as near *c*, is not a promising one.

Vertical Effects. The vertical effects of mounted plows are chiefly important because of the part they play in penetration and traction. The pull or force which the tractor exerts on the plow may increase or decrease the load on the drivewheels as compared with the static weight on them. The slip of both air tires and steel wheels is, within reasonable limits, reduced by added load, hence the force between the plow and tractor deserves study.

NOTATION (forces in pounds; dimensions in inches):

- *W*, Weight of plow
- L_1, directional component of soil resistance on plow, including friction and rolling resistance if any
- *V*, vertical component of soil force on plow bottom, but not including R_{2v}
- R_{2v}, vertical support supplied to plow by the furrow bottom or by a wheel
- *RV*, resultant of L_1 and *V*
- *PX*, directional component of pull (or draft), equal in amount to L_1
- *PZ*, vertical component of pull
- *PV*, resultant of *PX* and *PZ*
- *C*, intersection of wheel rim with the total soil force on the drivewheels. With air tires on level ground, it is slightly ahead of the vertical centerline of the wheel, but is taken at the centerline in this discussion. With steel wheels, however, it is distinctly farther ahead, 4 to 5 in being typical. In the drawings with this article one wheel is shown in the furrow and the other on the original surface. *C* is taken as the average position for the two wheels.
- X_1, vertical distance from *C* to *PV*.

PV is often called "line of draft". This is not a good term for it because many think "draft" should be used only for *PX*. Only confusion can result if *PX* is called "draft", but "line of draft" is said to be along *PV*. For this reason *PV* will be spoken of as "pull" or "line of pull" in the vertical plane.

The principles and procedure in analyzing vertical effects are as follows:

1 Determine the location and magnitude of *PV* for the soil conditions chosen. Obviously the pull on the plow is identical, except for direction with the pull on the tractor. It is the resultant of *W* and all soil reactions on the plow. In this connection it should be noted that *PV*, the line of pull, cannot be shifted except under definite limitations. If L_1 and *V* are constant, then *PV* can be changed only by changing the amount or location of *W* or R_{2v}.

2 Calculate the increase or decrease in drivewheel loading when the tractor is moving. A convenient step is first, at point *D*, directly above or below *C*, to resolve *PV* into its components *PX* and *PZ*. The change in loading from the static loading is caused by:

(a) Addition or subtraction of *PZ*.

(b) Load transfer from front to rear axle, or the reverse, due to *PX*. Its amount is *PX* multiplied by X_1 divided by the wheelbase.

(c) Load transfer caused by that part of the torque on the rear axle which is used to move the tractor. This always shifts loading from the front to the rear axle during forward motion. Its amount may be approximated by determining or estimating the rolling resistance, multiplying this figure by the no-load rolling radius of the drivewheels, and dividing by the wheelbase. This item of load transfer is not of much consequence unless the rolling resistance is high. With air tires having low rolling resistance, it is a small item as compared with the others.

3 The above changes in axle loading combined with the static load give the actual loading on the drivewheels when the tractor is moving. From this loading, the tractive ability of air tires particularly can be predicted with reasonable accuracy. Many experiments have shown that loading is by far the biggest factor in traction of air tires on surfaces which are not slippery. Sixteen per cent slip has been suggested as permissible. Tests of tractive efficiency, however, at the Iowa and Pennsylvania agricultural experiment stations show that this is usually too much slip for best efficiency in converting engine work into drawbar work. On a firm surface like sod, best efficiency is secured with about 8 per cent slip, while on a somewhat loose surface more slip is desirable. Only on a very soft surface, such as fresh plowing where the rolling resistance is high, will the efficiency peak come at about 16 per cent slip. A 10 per cent slip is about right for an average of the surfaces on which a tractor will do most of its work. On fairly good footing 10 per cent slip will occur when the draft, *PX*, is from 40 to 50 per cent of the actual wheel loading when in motion, after proper allowance is made for *PZ* and load transfer.

Two distinct types of mounted plows are being made as follows:

Type I. Pulled from one point, customarily the front of the beam. Attachments near the rear merely serve to prevent tipping to either side, not to exert any vertical force on the plow. Some trouble is reported because users have tried to use the rear connections to force the plow into the ground, not realizing their unsuitability for that purpose. In effect, the plow is merely a walking plow which is steadied sideways, it being free to take a position determined by the pull, the weight, and the total soil forces on it. This style is the one made by a number of implement companies and is illustrated in Figs. 2, 3, and 6.

Type II. Pulled from two or more points as seen from the side and having some degree of rigidity with the tractor. In one plow of this type, all plow weight and downward *V* is carried on the tractor since the sliding and rolling landside does not furnish vertical support. This feature, however, is a detail rather than an essential characteristic of Type II.

The two types will be analyzed for two typical soil conditions, the soil forces on the plows being based on a large number of plow tests in the tillage meter at Pennsylvania agricultural experiment station. They are not by any means the extremes sometimes encountered but are typical for the conditions given. Unless otherwise mentioned, rather uniform soil conditions will be assumed, since striking of obstructions presents an entirely different situation. Rolling colters and well-shaped shares are assumed in each case.

Soil 1. Fairly heavy silt loam sod with 15 to 20 per cent moisture, where the draft, L_1 or *PX*, of a 16-in plow

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[1]Mechanics of Plow and Tractor Hitches, AGRICULTURAL ENGINEERING, for November 1934.

[2]Using the Tractor Efficiently, Pennsylvania Agricultural Experiment Station, Bulletin No. 343, 1937.

FIG. 6 A TYPE I PLOW WITH THE CONNECTION AT THE FRONT OF THE BEAM ALTERED SO THAT A CHAIN CAN BE USED TO OBSERVE THE DIRECTION OF PULL ON THE PLOW AND TRACTOR

about 7 in deep is 800 lb and V is 120 lb downward. On two 12-in plows the forces are in the same proportion, or 1200 and 180 lb, respectively.

Soil 2. Same soil with 10 per cent moisture, in which case it appears practically dry. In this case L_1 is taken the same as before, but V is 107 lb upward on a 16-in plow. This reversal of V is due mainly to the rolling colter. Worn shares would give higher values of upward V.

A typical Type I plow in Soil 1 is shown in Fig. 2. W and RV are first combined and their resultant then combined with R_{2v} into PV. The value of R_{2v} is as yet unknown but is determined by the fact that PV passes through F and E. From this known slope of PV and its known horizontal component, the value of R_{2v} is determined. There is in this case some uncertainty as to the location of R_{2v}, but the possible error caused by this uncertainty is small. It will be observed that X_1 is small, being 2½ in as compared to about 17 in with a separate plow, but that PZ is larger. The net result with tractors of about 70-in wheelbase and this soil condition is practically the same increase in drivewheel load for the mounted plow in the position shown as for a separate plow, hence the same effect on traction.

Fig. 3 shows the same plow in Soil 2. PV must pass through F as before. It happens, however, that PV is exactly the resultant of W and RV. In other words R_{2v} is zero. This means that the limit of penetration has been reached, since an increase of upward V would lift the plow. To maintain depth with the greater V, either more weight should be added or V should be reduced by taking off the rolling colter. Actually the condition shown is unstable because there is no reserve to take care of momentary fluctuations of V above the average value shown, neither is there any reserve to provide for wear of the share. These facts would seem to make this an impracticable operating condition. It might be made practicable, however, by substituting a jointer for the rolling colter since that would reduce the upward value of V. A separate plow would usually operate in this soil, even with a rolling colter, because of its greater weight.

The mechanics of the foregoing would seem to require no proof. They can be verified, however, by experiment as in Fig. 6, in which a chain is used to show the direction of PV.

An ingenious combination of a Type II plow and a hydraulic lift is shown in Figs. 4 and 5. Approximate dimensions and weights for a two-bottom, 12-in plow are given because it was the only size to which the author had access for getting measurements and for field observations. Pivots G and I are the connections on the plow, while H and K are on the tractor. The upper member, IK, is a free link, but the lower one, GH, is usually not free. It is never held down, but in normal work it is held up by the lifting device. The effect then is the same as if G were held up by a chain. The hydraulic lift is controlled both by a hand lever and by the deflection of the spring near K, the spring deflection being a function of the draft. A dead point in the control valve holds the lift steady when the draft is nearly uniform. Under this condition the plow and tractor are connected at G and through link IK, which is equivalent to a rigid connection. In normal work, if the draft changes appreciably due to a difference in soil or depth, the spring deflection will change and the control valve will cause the lift to raise or lower the plow. The spring, therefore, regulates the depth to give nearly constant draft. Thus, in non-uniform soil, the depth will change with the draft unless the operator adjusts the hand lever for each change. Whether or not the constant draft principle of depth control will be generally accepted as satisfactory remains to be seen.

Fig. 4 shows this plow in Soil 1. PV is easily located by combining W and RV since there is no appreciable R_{2v}. This is merely another way of saying that all plow weight and downward soil force are carried on the tractor. It should be emphasized that PV is the pull of the plow upon the tractor regardless of where the connections are made. In this case the tractor is pulling on the plow at G with a force greater than PV and pushing back on it at I with a lesser force. In other words, PV is the resultant of the forces at G and along IK. At O, therefore, PV can be resolved into two forces, one acting through IK and the other at G. The force triangle for this set of conditions is given in Fig. 4

The large slope of PV and the large X_1 combine to give a large increase in drivewheel loading as compared with Type I or separate plows. It explains the good traction which this tractor exhibits, in spite of its light weight, when plowing where penetration is easy and the draft not too great. In Fig. 4 the increase is 835 lb. The tractor with operator has about 1280 lb static load on the rear axle, giving a total loading of 2115 lb. If the actual coefficient of traction is 45 per cent, then about 550 lb additional might be needed to pull the plow with 10 per cent slip.

In Soil 2, Fig. 5, all conditions are worse for traction. Part of the plow weight must be used for penetration instead of for traction and PV comes lower on the tractor. The increase on the drivewheels is about 375 lb, giving a total load of 1655 lb. Obviously the slip will be very high on a draft of 1200 lb unless a large amount of weight is added. This conclusion is confirmed by tests in soil where penetration is difficult. Here again the plow has nearly reached its limit of penetration as in Fig. 3. In fact, when fluctuations of V are considered rather than the average, it is probably beyond the practicable limit. This is because the force at G is now nearly in line with H. A small increase in upward V will put the force at G below H, and G and the plow will rise. Sharp shares will doubtless be necessary when the soil approaches this condition.

The foregoing for both types of plows is mostly for fairly steady conditions as distinguished from momentary effects when the depth is changing. With the Type II plow particularly, PV will be steeper when the lift is raising the plow, with a resulting momentary improvement of traction. Conversely, when the lift permits the plow to lower, PV will be flatter and traction less than average for an instant.

It will be observed that PV is always above C in normal work, hence load is transferred from the front to the rear axle. This conclusion is opposite to the claim frequently

made for this type of hitch. In Fig. 4, for example, about 325 lb is removed from the front axle.

When the plow strikes an obstruction, the situation is momentarily much different. The spring near *K* is then shortened abnormally. This is said to reverse the usual action of the lift control valve; that is, it releases the pressure in the lifting cylinder for an instant. Such action makes *GH* practically a free link. The effect is then equivalent to pulling the plow from a point ahead where the axes of *IK* and *GH* intersect. Momentarily, therefore, *PV* is low and comparatively flat, with a very low value of X_1. The drivewheel loading then becomes nearly the static weight and the wheels are likely to lose traction.

It is difficult to predict even approximately what the forces may be in the short instant of time because the inertia and the elasticity of the various parts are such a large factor. There is also uncertainty as to the quickness of action of the hydraulic lift. In practice, at moderate speed and with little additional weight, the wheels slip and the plow is not damaged. Probably only experience will show to what extent the speed and weight can be increased before damage occurs. The elasticity of the spring near *K* helps cushion the shock. The fact remains, however, that losing traction or declutching does not dissipate the kinetic energy stored in the plow and tractor, and no doubt at some speed the elasticity of the hitch parts will be inadequate for this fast-increasing energy.

In this connection it may be mentioned that some models used to explain this hitch have lacked the connection with the hydraulic lift; that is, *GH* has been a free link as well as *IK*. This is a vital change from the actual construction and any conclusions based on the model's action are likely to be in error.

In order to compare the separate plow and the two mounted types, Table 1 has been calculated for a 16-in plow weighing 220 lb, in each case with the same tractor. The tractor with average sized air tires, wheelbase of 70 in, and rolling resistance of about 120 lb, would have a load transfer of about 35 lb due to rolling resistance, and this item is included in the total increase in drivewheel load.

TABLE 1. COMPARISON OF REACTIONS FOR ONE SIZE AND WEIGHT OF PLOW

Type of plow	Soil condition	X_1	*PZ*	Total increase in loading
Separate	1	17	125	255
Mounted, I	1	2½	190	255
Mounted, II	1	15	340	545
Separate	2	17	112	240
Mounted, I	2[a]	6½	110	220
Mounted, II	2[a]	9	113	250

[a]Probably impracticable for reasons previously explained unless rolling colters are removed or plow weight increased. Both of these changes would alter the increase in drivewheel loading.

A forward position of the plow, such as *c*, Fig. 1, is unfavorable for traction. Either *PV* would be below *C*, or *PZ* would act upwardly on the tractor. Both would result in a small increase in drivewheel loading or in a decrease.

CONCLUSIONS

1 Mounted plows have an advantage over separate plows in working into corners and close to fences, in convenience of control, also usually in first cost. Depth and width control depend more on individual design than on whether the plow is mounted or separate.

2 Horizontal hitching is less favorable for a mounted than for a separate plow when the tractor is much wider than the plow. This applies particularly to a one-bottom plow, also to a two-bottom plow with a widetrack tractor.

3 For air tires, and to a lesser extent for steel wheels, there is as yet no practical substitute for loading in securing traction. This loading is not merely the static weight but includes the action of all forces which affect the actual drivewheel loading when the tractor is moving.

4 On average surfaces, as will be encountered in most plowing, the tractive efficiency of air tires is impaired by slip of more than 10 per cent. This slip will occur when *PX* is 40 to 50 per cent of the total drivewheel loading when in motion.

5 In normal work, both types of connections described between the plow and the tractor produce similar vertical effects on the tractor, differences being only of magnitude. The exact effect is determined largely by the slope and position of *PV*, which in turn is much influenced by whether all plow weight and downward soil force is carried on the tractor.

6 Carrying on the tractor of all plow weight and downward soil force assists traction. Much of this benefit is lost, however, when the soil force on the plow is upward.

7 When penetration is easy, typical Type I plows have about the same effect on traction as a separate plow. The Type II plow described has an advantage in this condition for the reason given in the preceding paragraph.

8 When penetration is difficult and rolling colters are used, any light mounted plow is at a disadvantage. All weight used to keep the plow in the ground is not available for traction. Most practicable remedies seem to be to remove the rolling colters, or to add weight on the plow, or on both plow and tractor.

9 With tools which require considerable weight for penetration, such as ordinary disk harrows, the Type II hitch has little, if any, usefulness.

Room for Improvement

CAREFUL study of a wide range of typical livestock, dairy, fruit, truck, and general farms throughout Virginia shows each and every one capable of improvement in their physical plants and their management regardless of size, type, and location.

Some of the factors that reduce the efficiency of farm operations are too much or too little land; unbalanced land use; neglect of soil improvements; improper cropping practices; poor field arrangement; improperly located roads, lanes, fences, and ditches; unbalanced crop and livestock schedules; lack of satisfactory power, machinery, and equipment; costly use and poor distribution of labor; inadequate service buildings; inconvenient farmstead and buildings; inadequate tenant houses; lack of adequate farm business records; and lack of long-time objectives and determination to carry out a definite program of permanent improvement.

Plans can be developed for the whole farm to achieve good balance in the development, use, and conservation of land, buildings, power, machinery, capital, and labor, and a program of permanent improvement can be carried out for the more efficient operation of the farm and to provide more wholesome working and living environment for the farm people.—*From "Farm Operating Efficiency Investigations in Virginia, 1931-1938" (progress report) ACE-29.*

Determining Value of Buildings to a Farm

By J. C. Wooley
MEMBER A.S.A.E.

APPRAISAL of any farm improvement consists of two steps, namely, determination of the mechanical value of the structure in its present condition, and the evaluation of the structure to the farm on which it is situated. The first step in the appraisal process is quite well developed.

Ways and means for determining the replacement or the construction cost of buildings have been developed by contractors making bids on construction work. These men must have accurate estimates, and this need has made it worth while for different individuals to devote considerable time and energy to the development of the effective methods available. Cost estimates for new farm buildings are being predicted with varying degrees of accuracy by the cost-per-animal method, by cubing, or by the material-cost-plus-labor method.

Where buildings are already built and in use, it is necessary to charge off a certain amount of the replacement or new cost to take care of this use. Fig. 1 shows a number of curves that may be used to determine the amount to be charged off for depreciation at any time in the life of a structure. Depreciation rates, maintenance costs, etc., do not differ greatly in different farm buildings, when figured on percentage of life, and, therefore, the curves will be quite satisfactory for all service buildings.

The straight line has probably been used to a greater extent than any other, although it is usually considered to give a very distinct advantage to the buyer. In other words, the curve gives too low a value at all points. The so-called "second-hand", or Matheson, curve gives values that are consistently low for farm buildings because they have but little resale value.

The equal profits ratio curve developed by J. C. L. Fish, in his "Engineering Economics", seems to fit our needs to better advantage. It gives higher values in the earlier part of the life of the building, and gives rapidly decreasing values during the latter part. This curve is based on a number of factors that are so evaluated that they give an equal ratio of profits to both buyer and seller.

By securing the proper amount of depreciation from one of these curves and deducting it from the replacement or new cost previously determined, the present worth without relation to its location is secured. This is a mechanical value. If the building in question is a barn and is located on a farm where it meets the requirements, then the full mechanical value is the appraised value. If the barn has twice the capacity needed, then fifty per cent times the mechanical value would give the appraised value or the present worth to the particular farm on which it is situated. In case the surplus structure had a junk or resale value, this should be added to this appraised value.

The building needs of any farm depend upon the land-use program needed on that farm, the productivity of its soil, the type of enterprises suited to this land-use program, and the available market.

Determining the building requirements of a farm is sometimes a long and tedious process. It is the purpose of this paper to present a method which has been worked out for Missouri conditions, for saving time in this process, and which, when properly modified, it is hoped can be applied to other sections.

This method takes into consideration the productivity of the land, the acres in permanent pasture, and the number of acres in cultivation. It is planned with the idea that practically all the crops raised are to be fed on the farm. In determining the feed requirements per animal, it was assumed that animals were in a healthy condition, free from parasites, and under better than average farm management.

This system leaves the selection of enterprises adapted to the situation to the appraiser, since there are so many factors involved in making this choice. This strengthens rather than weakens the system because it permits a closer fitting of the system to the particular farm.

For purposes of use in the method, the various soil areas have been grouped as shown in Table 1.

Pasture land has been divided on the basis of fertility into five classes, and the cultivated land into four classes. The acres of pasture needed for one dairy cow and the cultivated acres needed per cow are used as one pasture and one cultivated unit, respectively. The number of pasture and of cultivated acres of each land class was computed for each type of animal. The dairy cow was taken as a standard for comparison, and other animals were given a rating in proportion to their feed requirements as compared to the dairy cow (Table 3).

In order to facilitate the application of this information to a problem, it was arranged graphically as shown in Fig. 2. In using this chart the pasture units should be checked first to see that they are fully utilized, because pasture is something that cannot usually be sold off the farm. If the pasture will carry a greater amount of livestock than can be fed from the cultivated acres, then it will be necessary to buy some feed if the farm is operated up to capacity. On the other hand, if the cultivated acres overbalance the pasture, then the special pasture programs may be used to bring the farm to maximum production, or dry-lot feeding

Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 6, 1939. The author is professor and head of the agricultural engineering department, University of Missouri.

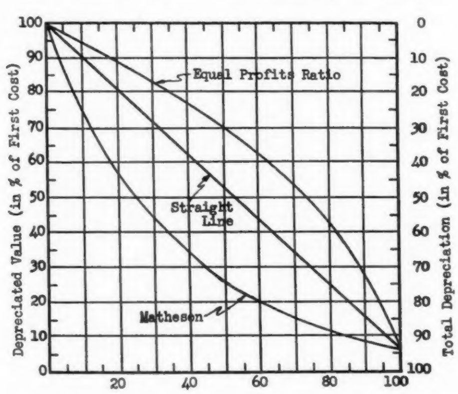

FIG. 1 DEPRECIATION OF BUILDINGS AS DETERMINED BY DIFFERENT METHODS OF COMPUTATION

TABLE 1. SOIL PRODUCTIVITY CLASSIFICATION

Class	Description	Principal upland series
I	Productive land, all suitable for cultivation. Average corn yields, 40 bu or more per acre.	Marshall Grundy Summit
II	Above medium productivity, all suitable for cultivation. Average corn yields, 30 to 40 bu per acre.	Edina and Carrington better grades of Knox, Shelby and Pettis
III	Land of medium productivity, practically all tillable. Average corn yields, 20 to 30 bu per acre.	Crawford Decatur Eldon Hagerstown Leslie Memphis Oswego Putnam
IV	Below medium productivity. May or may not be tillable, but suitable for pasture. Average corn yields below 20 bu per acre.	Bates Baxter Cherokee Lindley Tilsit Union Gerald
V	Mainly forest or rough pasture, because of low fertility, rough surface, erosion, stone content, or wet condition.	Ashe Boone Clarksville Hanceville Marion Lebanon

may be resorted to in order to utilize the farm to the best advantage.

I would like to use this chart, by way of example, to determine the building requirement for a farm of 160 acres, 40 acres in pasture, and 120 in cultivation, having Marshall soil, grading No. 1 in productivity. The enterprises, in order of importance in this area are beef cattle, hogs, and poultry. Referring to Fig. 2, we find that the 40 acres of No. 1 pasture would supply 28 pasture units; since beef cattle is one of the leading enterprises in this section, let us select beef cows with calves fed out in the fall. Each cow and calf requires 1.27 (Table 3) pasture units, and therefore 28 divided by 1.27 equals 22 cows and calves, the correct number for the 40-acre pasture. Each cow and calf requires 0.85 cultivated units. Therefore, 22 times 0.85 equals approximately 19 cultivated units, or 44 acres, of No. 1 class of land required. Assuming that the farm is to have 500 hens, we find that they will require 5.85 cultivated units, or about 14 acres. This leaves 62 acres, or 27 cultivated units, for hogs. Dividing 27 by 2.4 gives 11 sows with 13 pigs each year (two litters). If the farming is done with horses, one of the enterprises must be decreased to allow for them.

The buildings on this farm should be studied to ascertain whether or not they will furnish satisfactory housing for these enterprises and their value determined accordingly. If they are too small, but are built in such a way that they can be enlarged without extra cost, then they should be appraised at their full mechanical value. If expensive

TABLE 2. FEED UNIT ACREAGE OF SOIL PRODUCTIVITY CLASSES

Soil class	Acres per pasture unit	Acres per cultivated unit
I	1.50	2.25
II	1.75	3.25
III	2.25	4.50
IV	3.00	6.00
V	4.00	

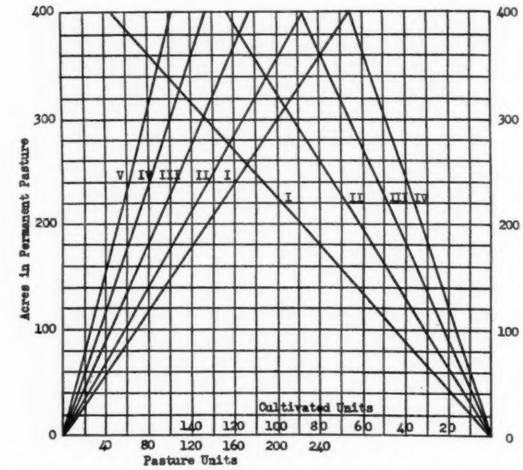

Fig. 2 Graph for determining the animal feeding capacity of a farm in terms of pasture and cultivated units, based on a classification of soils into five groups according to productivity. To use, locate the number of acres of any soil class on the index at the right or left side, follow horizontally to the intersection of the soil class line, follow down from this point, and read the equivalent units on the appropriate scale at the bottom. Totaling units for all soil classes on the farm gives a guide to effective land use, livestock feeding capacity, and building requirements

alterations will be necessary, this should be deducted from their mechanical value to determine their actual value to the farm.

The importance of building equipment in securing correct land use cannot be overemphasized. If a farm is equipped to house the kind and number of livestock that should be kept, it will have a strong influence toward securing the desired result. With a large number of tenant farmers and the frequent change of tenants, it will logically result that the dairy farmer will be attracted to the farm that is equipped for dairying; and the hog man to the hog farm.

It is my opinion that equipment planned for proper land use will have a greater influence in securing this proper land use than any other single factor. This by-product of the appraisal program may have important and far-reaching influences.

ACKNOWLEDGMENT: Credit is hereby given to Charles M. Timm, a 1939 graduate of the University of Missouri in agricultural engineering, who did a considerable part of the original research work on this problem.

TABLE 3. PASTURE UNITS PER ANIMAL

Kind of livestock	Units required[a] Pasture	Cultivated[b]
Dairy cow, full grain ration	1.00	1.00
Family cow	1.26	0.85
Dairy heifer, second yr	0.87	0.68
Dairy heifer, first yr	0.40	0.42
Beef cow and fed calf, sold in fall	1.27	0.85
Beef yearling, full fed, dry lot, no silage, 140 days	———	0.46
Ewe with lamb, sold early	0.210	0.092
Lambs, western, fed in dry lot	———	0.164
Sow, including 13 pigs, sold at 200 lb	———	2.40
Hen	———	0.0117
Work horse	0.570	0.910
Colt, first year	0.800	0.738
Colt, second year	1.000	0.930

[a]Data taken from Missouri Extension Circular 375.

[b]Cultivated units include pasture in rotation, legume hay, and row crops

The Relationship of Agricultural Engineering to the Flood Control Problem

By Mark L. Nichols and E. R. Kinnear
FELLOW A.S.A.E. MEMBER A.S.A.E.

ESTABLISHMENT and maintenance of a permanent, well-founded, prosperous agriculture is one of the great needs of this nation. This of necessity includes (1) conservation of the soil and its fertility, (2) conservation of the natural supplies of moisture in the soil, and (3) the regulation and conservation of water to provide security against flood ravages, all assuring protection for homes and property improvements. The Soil Erosion Act (Public 46) April 27, 1935, establishing the Soil Conservation Service, and the "Omnibus" Flood Control Act of June 22, 1936, together with subsequent amendatory legislation, have authorized and directed those prescribed activities for and in the Department of Agriculture.

Certain specifications must be met before federal funds can be allotted under any of this legislation. For example, in the field of flood control it must be shown that benefits will accrue equal to or greater than the costs of contemplated improvements, and presumably the expense must be prorated as nearly as practicable to the beneficiaries. Whether the main financial burden is to be borne by flood control or conservation interests may be difficult to determine, since they are intimately related and both concern themselves with practices designed to store water in soil and retard runoff.

Presented before the Soil and Water Conservation Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 7, 1939. The authors are, respectively, assistant chief in charge of research, and agricultural engineer, Soil Conservation Service, U. S. Department of Agriculture.

"Production of crops is the principal objective in the design and use of farm machinery. This undoubtedly will always be true, but future experience and new data may indicate that there is tangible relationship between farm economy and watershed economy. As and when such relationship can be established to the satisfaction of farm operators and other related public interests, agricultural engineers may find that some modification of practice or design should be made in the interest of flood control"

In spite of the inherent limitations as to basic data underlying each local flood problem, it seems necessary not only to allocate probable flood damages and expected benefits attending the application of remedial measures. but also to attempt the segregation of interrelated or interlacing influences, for example, flood control with incidental conservation benefits, or the reverse.

The term "flood control" as it relates to agriculture on a watershed is defined in the 1936 Flood Control Act as "measures for runoff and waterflow retardation and erosion prevention—for flood control purposes." This definition more accurately integrates agricultural flood control with the well-established usage of the term as it has been applied to waterways.

Previous to the time when the relation between agriculture and flood control became recognized through legislation, agricultural engineering had focused its varied agricultural knowledge mainly upon the economy of agricultural lands for the individual farm unit. As we approach the concept of watershed improvement, we must continue our primary interest in the economy of the individual farm unit, but, in addition to that, we are charged with interest in the physical and economical factors of all lands and farms on a watershed and the effect of the application of measures for flood control purposes on the regimen of the watershed as a whole. This immediately confronts us with the problem of determining the relationship between agricultural land use and the interests in a watershed of other urban, industrial, and public groups.

These additional interests which agricultural engineering must serve, above the physical and economic efficiency of the individual farm unit and the use of agricultural lands under either private or public ownership, may be described in specific terms of flood control as follows: (1) Dependence of urban and industrial values upon the maintenance of agricultural land values; (2) protection of major engineering structures such as reservoirs and channel improvements from sedimentation; (3) provision for water storage for protection from downstream flood and sedimentation damages and reduction in cost of channel improvements and floodways, with full consideration for the objectives of other interests such as the War Department flood control plans, and water utility needs, such as irrigation, power, domestic use, and elimination of pollution; and (4) reduction of localized flood and sedimentation damages that will not be reduced by nonagricultural flood control programs.

The titles of certain of the technical committees which have been developed by the American Society of Agricultural Engineers give us a good indication of the objective divisions of agricultural engineering science that have been directed toward physical and economic efficiency in the use of agricultural lands and the individual farm unit. They

are (1) hydrology, (2) reservoirs and ponds, (3) soil and water conservation, (4) soil preparation and tillage, (5) contour furrowing, (6) machinery design and use in terraced-land operation, (7) control of gully erosion, (8) irrigation and supplemental irrigation, (9) land drainage, (10) rural electrification, and (11) rural sanitation.

These divisions will now be concerned also with additional relationship to the flood control problem, and can direct their scientific equipment toward designing measures for flood control purposes which will result in the physical and economic efficiency of watersheds as well as the correct use of agricultural land *per se*.

HYDROLOGY

In the field of hydrology, the relationship to flood control offers a challenge to develop data and techniques for use in both the design and evaluation of measures for flood control purposes. The infiltration method of determining runoff lends itself admirably to more accurate design for measures for flood control purposes, and as a basis for the evaluation of the resulting flows that can be expected from runoff and waterflow retardation. The determination of basin water losses from known hydrographs and storms yields an overall check on infiltration capacities which may be determined for varying physical conditions on a watershed. The possible modification of infiltration capacities resulting from measures for flood control purposes (both vegetative and mechanical) requires an evaluation of such measures for both the benefit of the individual farm and the watershed organization. The possible change in the sequence of the entrance of tributary flood flows into the main stream is also an important problem.

Because of the complex nature of land and water problems on most watersheds, the design of flood control programs demands an aggressive and rigorous investigation and evaluation of the entire hydrology of the watershed, including tributaries and watershed slopes. Such investigations and evaluations should deal with both the natural occurrences of precipitation and runoff, and the techniques and methods of water control and usage for civilized purposes throughout the watershed, including duty of water for land use, irrigation and supplemental irrigation, power, domestic use, and the desired control of channel flows and silt movements. The adequacy of the economic evaluations of measures for soil conservation and flood control purposes will depend in turn upon the adequacy of our hydrologic conclusions regarding the complex land and water problems on the entire watershed. It is an urgent matter that agricultural engineering take inventory of its great accomplishments in the field of hydrology and prepare careful plans for extending the field into the broad scope of watershed improvement for flood control purposes.

When designing reservoirs and ponds for domestic use, irrigation, water conservation, recreation, erosion control, and related uses, additional provision can often be made for flood control purposes. In like manner when designing reservoirs and ponds for flood control purposes, beneficial agricultural and multiple other uses can be provided for.

The extent to which flood control provisions should be considered when designing reservoirs and ponds for agricultural and related purposes will depend upon the economy of flood control storage on the particular watershed in question. Another factor which enters into this consideration is the availability of basic hydrologic data which is required to evaluate and route the flows from numerous smaller structures, so that they may be definitely related to flood damage occurrence.

Reservoirs and ponds have been designed and constructed by agricultural engineers for many purposes and under many conditions. In few instances, however, have such structures been designed for flood control purposes *per se,* since the Corps of Engineers of the War Department is charged with the responsibility for such structures. There is no adequately established criterion for segregating little waters from big waters, but it is anticipated that conscientious cooperative studies and the experience of the Departments of War and Agriculture will result in clearly defining the relative values of control measures which will be used to improve watersheds for flood control purposes.

An article by Mr. T. B. Chambers, entitled "Engineering in Soil and Water Conservation" in the January 1939 issue of *Soil Conservation*, summarizes the fundamental methods of erosion control and water conservation as "(1) the improvement of the structural characteristics of the soil, (2) the use of vegetation to bind the soil in place, and (3) the interception and diversion or storage of surface runoff." These fundamentals of conservation are basic to flood control, and in most instances the measure applied will not only result in benefits to the agricultural lands on which applied but also in benefits to other lands and structures for flood control purposes. The flood control problem, however, usually places additional emphasis upon the interception, diversion, and storage of surface runoff, and often necessitates additional structural treatment.

The benefit to individual farms, and agricultural lands *per se,* has been the principal measure of evaluation of soil and water conservation. In the field of flood control the determination of flood control benefits in terms of both silt and water throughout a watershed and the evaluation in dollars or comparable values presents a challenging problem to agricultural engineering.

INDIVIDUAL WATERSHED INFLUENCES ON FLOOD CONTROL BENEFITS

A comprehensive and intensive study of each watershed is required in order to make the determinations and evaluations of flood control benefits of soil and water conservation measures. This study will bring out new and engaging and practical concepts of the value of factual data dealing with soil infiltration capacities, precipitation frequencies, and design storms for different frequencies, and the effect of soil and water conservation measures under such storm conditions on the flows from tributary streams. It will be necessary to determine the relative amounts of sedimentation reduction resulting from erosion prevention by means of studies of erosion on watersheds and of deposition in stream channels. These evaluations necessarily will be applicable under the specific climatic, physical, cultural, and cover conditions existing at the time when design storms are expected to occur. Experience has shown that soil and water conservation measures on some watersheds will have tremendous flood control values during summer conditions, and little or none under winter conditions.

The primary objective of soil preparation and tillage is to maintain the soil in the best available condition for plant growth. The efficiency and economy of the resultant plant growth have a material influence on two of the basic factors of the flood control problem, namely, the infiltration, distribution, and movement of water in the soil and on crop transpiration losses and the stabilization of the soil surface to prevent erosion. In flood control we are called upon to evaluate these factors as they effect runoff and silt production throughout the changing conditions of the annual climatic cycle and as far as possible during abnormally wet or dry cycles over extended periods of years.

The development of more adequate data for making

"SOLVING THE FLOOD CONTROL PROBLEM PLACES NEW REQUIREMENTS ON SOIL PREPARATION AND TILLAGE. NEW METHODS DEVISED TO MEET SUCH REQUIREMENTS, HOWEVER, MUST REMAIN WITHIN THE LIMITS OF FARM ECONOMY." ONE SUCH METHOD, PARTICULARLY ADAPTED TO FIELDS OF MODERATE SLOPE WHICH ARE LEFT BARE OVER WINTER IN AREAS WHERE CONSERVATION OF FIELD MOISTURE IS IMPORTANT, IS CONTOUR BASIN LISTING

such evaluations might readily influence the methods and techniques of soil preparation and tillage. An example of this is the contour listing of cultivated fields in the fall to conserve winter moisture, as new extensively practiced in the western areas of low rainfall. This study is still in its early stages, but it is already apparent that solving of the flood control problem places new requirements on soil preparation and tillage. New methods devised to meet such requirements, however, must remain within the limits of farm economy.

Many questions have arisen and much has been written concerning contour furrows. Generally speaking, the balance of opinion is in favor of this type of land treatment, based upon results in the form of erosion control, effective water conservation, and certain reductions in surface runoff. The exact conditions under which this practice is effective have not as yet been clearly defined.

Flood control places a decided emphasis upon the probable magnitude and permanency of the reduction in runoff and erosion. We should examine contour furrows (pasture and terraces) in the light of this emphasis. Some of the factors involved are the influence of seasonal climatic changes on the effectiveness of contour furrows and similar structures, the permanency of runoff reduction as limited by the efficiency and economy of maintenance, the possible modification of design to increase amount of water storage and the limits of such modification set by farm and ranch economy, and the comparative economy between the storage of surface water and the storage of channel flows.

Conditions on the North Concho watershed in Texas serve as a good example of the relationship between mechanical treatment on range land and the flood control problem.

Range land comprises 96 per cent of the watershed. On a demonstration project within the watershed, inaugurated in 1934, contour furrows, lister furrows, and some pasture terraces, have effectively reduced erosion and runoff to a minimum, resulting in benefits to the rancher and to flood control, even under near maximum storm conditions. The average size of land unit within the demonstration area is 300 acres.

The major portion of the balance of the range land in the watershed consists of larger land ownership units, from several thousand to 25,000 acres. Treatments justified on the 300-acre units are not so justified on the large units, from the land owner's point of view, because of the relatively higher amount of labor per acre involved in maintenance.

The amount of reduction of runoff from the measures, the permanency of the storage, and the fact that such storage of surface waters cost approximately $10.00 per acre-foot, as against $22.00 per acre-foot of storage by large dams, makes the installation of such mechanical treatment of pastures economically justifiable for federal flood control funds, in this case with partial contribution from the land owners. This mechanical treatment is also within the practical economy of land use by the individual land owners on this watershed.

The improvement in vegetative types resulting checks with the results on the Stillwater Creek, Oklahoma, watershed, where contour furrows have been installed for 13 years, and shows marked replacement of inferior vegetation by superior and more palatable types.

Production of crops is the principal objective in the design and use of farm machinery. This undoubtedly will always be true, but future experience and new data may indicate that there is tangible relationship between farm economy and watershed economy. As and when such relationship can be established to the satisfaction of farm operators and other related public interests, agricultural engineers may find that some modification of practice or design should be made in the interest of flood control. Some recognition of this has already been made by the Department of Agriculture in that it has facilitated the rental of larger and newer types of multiple-purpose equipment to farmers, counties, and others.

The control of gully erosion is often definitely related to flood control. The acceleration of runoff caused by gullies and the quantities of silt thus produced may contribute directly to the magnitude of flood damages. The control of field gullies is a function of soil and water conservation on the farm. The broader aspect of watershed improvement provides economic justification for controlling the secondary gullying of tributary stream channels which has often been too costly for the individual farmer to cope with. Watershed improvement plans often will include the necessary stabilization of the profiles of tributary stream channels as a matter of federal interest when local contribution cannot be expected from the farmer because the secondary cutting of stream channels may not immediately affect his farm economy.

The flood control problem places new emphasis on the control of stream-bank erosion which is a major erosion problem on many watersheds. In many instances, federal

cost has not been justified by individual farm values, and the cost of stabilization has been too much for the individual farmer, even though he considered the cost of control as justified. With flood and sedimentation damages downstream providing sufficient values for economic justification, the control of stream-bank erosion will be carried out on many watersheds with both local and federal contribution. In the interest of economy and efficiency, designs for control measures will provide for full use of materials available locally and reduction of maintenance by zoning from grazing. Many successful control measures have been carried out under varied climatic and physical conditions throughout the country, and it would be of great value to agricultural engineering to take inventory of its accomplishments in this type of work and make some recommendations as criteria for future guidance.

We are all familiar with the splendid development of highway drainage and erosion control in many parts of the country. This type of work is an important part of watershed improvement and will be expanded because of the additional flood control values. The modification of both highway and railroad drainage can make an important contribution to flood control storage.

IRRIGATION AND FLOOD CONTROL

The relationship between all types of irrigation and the flood control problem is the most difficult one of all to cope with. In a recent flood control memorandum[1] issued by the Department, the following statement was made:

"The appropriations or grants of water rights on a great many western streams have been so large as to cover every conceivable flow of that stream both as to total volume, and as to seasonal distribution. This means that there are a large number of unsatisfied demands on the stream under normal or less than normal runoff conditions. Although flood flows may damage some people, yet there are others who are interested in securing the maximum total runoff from a watershed regardless of its seasonal distribution. This is particularly the case when storage capacity greatly exceeds normal runoff available for storage. Under such circumstances, holders of water rights are unwilling to favor any diminution of total runoff for erosion control or flood control purposes."

We usually cannot "have our cake and eat it too," and it is incumbent upon agricultural engineering to determine, in so far as possible, the best economic distribution of water on watersheds where irrigation is a problem. If we retard water to prevent erosion, conserve water for the benefit of upland farms, and store water for flood control purposes, what are the effects upon irrigation and ground water supplies? There is in most instances an acute lack of data with which to make this determination, and the legal aspect of water rights places the engineer in a complex situation.

Now, for the first time, requirements of a comprehensive flood control project on watersheds afford the opportunity to attack this problem from all angles on a given watershed, toward the end of establishing basic data as a foundation for assigning proper values to the various phases of water utility.

To accomplish this it will be necessary to take inventory of available hydrologic and legal data at all sources, make whatever stream gaging installations are required, and to place the most experienced engineering minds on the solving of the problem. Our future findings may materially influence our concepts of the relative economy of various water control programs. One thing is certain, in watersheds where irrigation is already legally established we cannot embark upon a comprehensive program of land use, erosion prevention, and flood control until we have thoroughly prepared a ground work of hydrologic data and water economy, including the economic effect of sedimentation on permanency of water supplies. The extent to which supplemental irrigation can be developed is very dependent upon prior consideration of water economy in a watershed. In this field, agricultural engineering should obtain the cooperation and consulting advice of other engineering individuals, groups, and societies in order that final conclusions may have the support of any other interests involved.

Land drainage is often related to the flood control problem. Poorly drained soils on sloping agricultural land are usually treated with surface drainage channels or subsurface conduits. The effect of this type of drainage on flood flows is somewhat problematical, since the effect is to increase the infiltration capacity of the soil, but it may also return subsurface flow to available natural channels at a rapid rate, which would make the subsurface flow a part of the flood flow hydrograph. When soils of this nature predominate on a watershed, it is possible that additional storage for flood control can be provided by detention dams.

The drainage of bottom lands within the flood plain is naturally influenced by the regulation of flood flows. The size and cost of ditches may be reduced and the cost of maintenance may be reduced through modified flood flows and reduced sedimentation, thus increasing the efficiency of drainage works. Certain drainage channels may also be designed for the dual purpose of drainage and flood control. The broad experience of agricultural engineering in drainage work can contribute substantial hydrologic and soils data to the field of flood control.

Domestic use of water and stream pollution are closely related to flood control and drainage, and require full consideration by agricultural engineering through development of rural sanitation plans.

WATER POWER VALUES ASSOCIATED WITH FLOOD CONTROL

The development of water power is important to human welfare and has economic value on many watersheds. Agricultural engineering has contributed much through its interest in the development of rural electrification. Here again there is a significant relationship to the flood control problem. When rural electrification can be economically justified, this utility of water stored for flood control purposes increases materially the benefits from flood control. In some cases, flood control *per se,* and rural electrification *per se,* may not be economically justified of themselves but the dual benefits may justify the total cost involved. It is desirable that rural electrification be given full consideration in the development of watershed improvements for good land use and flood control.

It would seem readily apparent that the intensive development of the relationship of agricultural engineering to flood control problems is a big job. Many interests and activities must be woven together into a plan for watershed improvement. It is essential that research assist with definitions of technical fundamentals. Analysis and interpretation of basic data in the light of old and new concepts must be meticulously carried forward to meet the demands for field application. Some of the definite conclusions regarding physical and economic evaluation of measures for flood control purposes may require some years of further research. Future research projects can be planned to provide data which will have a broader application to the complex needs presented by land and water problems.

It is probably a fact that much research data has been accumulated more rapidly. *(Continued on page 181)*

[1]Soil Conservation Service Field Memorandum 58.

Ultraviolet and Infrared Energy in Agricultural Practice

By L. J. Buttolph and L. C. Porter
FELLOW A.S.A.E.

BEYOND the visible spectrum of the sun are ultravisible regions of radiant energy known to us from the remarkable heating and sunburning effects experienced at high altitudes and under conditions of very low air temperature. These effects have long been recognized as unique but have generally been taken for granted, and it is only in trying to obtain them from artificial sources that we have thought of their nature. This paper will review the reasons for the new interest in ultraviolet and ultrared or infrared energy, and suggest the times and places where each may be used to advantage in agricultural practice. There will be a discussion of ways of conserving and utilizing the ultra-visible energy of the sun with emphasis on the practical use of artificial sources.

Fig. 1A shows the relative spectral distribution of the radiant energy from the sun and from typical artificial sources. On the same wave-length scale are plotted typical effect curves, Fig. 1B, of the three spectral regions. While there are many other effects on photographic materials, plant life, and bacteria, the ones shown lend themselves to this graphic treatment. It is of interest to note the fit of the eye sensitivity curve to the sun's energy distribution, a fit which becomes closer with all the natural variations in sunlight in the direction of reducing the blue end of the spectrum. That the eye sensitivity curve is even narrower in range than sunlight is doubtless an adaptation to secure the advantages of achromatic vision which we have learned to further improve by the addition of yellow-green glasses.

The unconscious use of ultravisible energy is old in farm practice, but its intelligent utilization from artificial sources is relatively new. As available from the sun, ultravisible energy, like electrical energy, only produces heating or an erythema when absorbed in the proper material. Unlike electrical energy, it does not require a conductor for transmission through space, but as a result is somewhat more difficult to control in transit as its straight-line course can only be changed, in an angular way, by reflectors and refractors. Air, water, and glass are of immediate interest for their effect on radiant energy (Fig. 1C). For practical purposes, air has little effect on the energy in which we are interested, ordinary glass absorbs the shorter ultraviolet, water absorbs the longer infrared, and a typical special glass transmits all but the longest infrared. We are similarly interested in typical reflector materials (Fig. 1D). They differ more in average reflectivity than in the variations of reflectivity with wave length, and other physical characteristics may dictate a choice.

Although the basic principles of the production and utilization of ultravisible energy are the same as for light, the practical uses are entirely different, and there is also little similarity in the legitimate uses of the ultraviolet and infrared.

Heating produced by the absorption of radiant energy or of electricity is a basic process which should be clearly distinguished from the secondary process of heating by contact and conduction, which involves only a transfer of heat from one material to another, as is illustrated by the heating of a soil surface to a temperature above that of the air, by the sun's radiant energy on the one hand, and by conduction from a buried electric heating unit on the other hand. It is generally recognized that effectiveness of the latter process is largely conditioned

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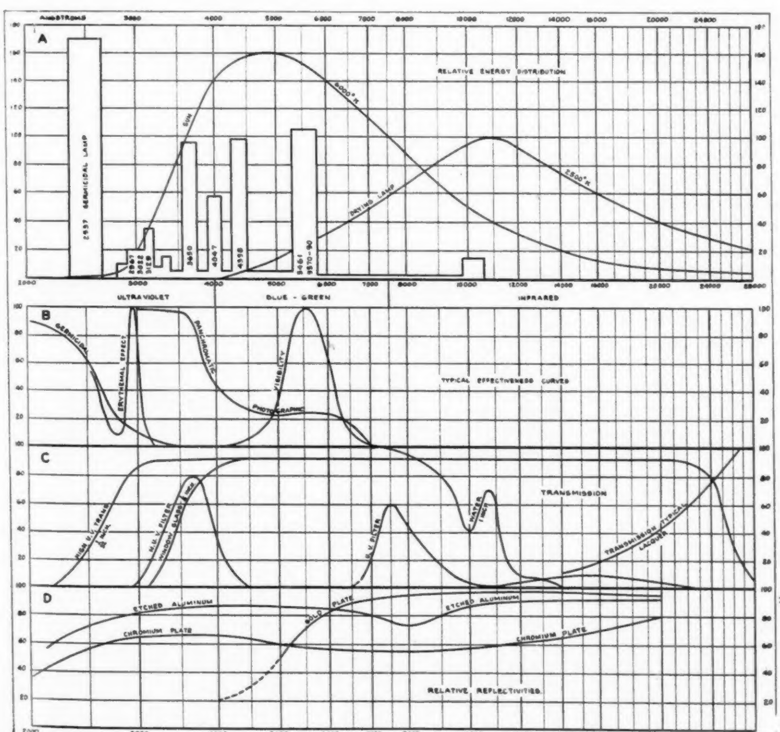

FIG. 1 ENERGY DISTRIBUTION, TRANSMISSION, AND REFLECTIVITY CURVES

on the nature of contact between the source of heat and the material to be heated, that the practical problem is to obtain a free flow of heat across the boundary surfaces between. This necessity of actual contact entails a large number of familiar limitations. Fluids must be handled in containers neutral to them as well as to the source of heat, be it another fluid or a heated solid. Fluids, as either sources or receivers of heat, must be stirred to facilitate contact with the surface of heat transfer. In general, this surface is at the lowest temperature of the source and the highest temperature of the heated material, the latter often being a serious limitation.

An example of infrared heating of interest from a theoretical standpoint is that of the common hotbed or greenhouse. In it full advantage is taken of the fact that, as indicated in Fig. 1C, ordinary window glass readily transmits most of the infrared from the sun, but will not transmit the much longer wave energy radiated back from the soil at the highest temperature it ever reaches. This, combined with the restricted air circulation makes the glass hotbed or greenhouse an unique trap for radiant energy. Similar principles are involved in some of the solar heaters, cookers, and power boilers being developed by Dr. C. G. Abbott. It would seem that the use of extensive areas of glass in the roofs and south sides of farm buildings merits some study for the possibility of heated dry air for the final curing of hay and grain in the summer, at the cost of upsetting some farm traditions.

In general terms, the advantages of heating by the direct application of infrared energy result from the fact that, by the design of the artificial source or the filtration of the sun's energy, the wave length of maximum intensity may be adjusted to fit the absorption of the material in such a way as to insure either surface heating or deep penetration and internal heating as illustrated in the method of infrared drying recently described by Ickis and Haynes.

Before suggesting the use of artificial sources of infrared, there should be a gesture of respect to the sun and a word of caution as to attempting to duplicate the intensity and the effectiveness of the direct, midday, midsummer radiant energy from the sun, which is comparable with that of a bare 1500-watt incandescent lamp at a distance of one foot from the surface receiving the energy. Assuming very efficient reflectors, this means that an extensive area could be irradiated to this intensity at the rate of about 100 watts per square foot. Such an intensity is available from the sun for an uncertain and limited time, while artificial sources permit any desired intensity at any time.

It seems obvious that with the coming of general rural electrification, infrared heating will have extensive application because of the simplicity of the equipment, the low fire hazard, and the possibility of simulating natural sun-heating effects in the care of both plants and animals. The extension of the use of the domestic electric radiant heater and the incandescent type of infrared heater to the poultry house and to the supplemental heating, especially of newly born animals of all kinds, is a natural move waiting only for lower cost electricity and more suitable equipment. There are many minor heating jobs commonly done with electric space heaters of the strip type that are inherently more suitable to infrared heating, such as keeping automobile radiators from freezing and freeing windows from ice and fog. It is important to remember that the conversion of the electricity into heat is just as complete and efficient in the case of the incandescent infrared source as of the lower temperature space heater, the flat iron, or the electric stove. Of course, any source of infrared energy is itself hot enough to be also a source of some heating by conduction and contact with the surrounding air, but it has the additional unique advantage of the long-range transmission of radiant energy. In short, in any case where electric heating is economical, consideration should be given the possible advantages of infrared sources.

It is suggested that infrared drying may be effectively used to hasten the drying of newly threshed grain to prevent spoilage. It might even be used to advantage to obtain the little additional drying necessary to prevent the molding of hay and grain by proper placement of units over the mow during filling. If the electrical energy were available, infrared heating would have inherent advantages over the use of hot air in ordinary types of hay driers for field use. Just as use of infrared energy with or without hot air is finding new industrial applications, so there should be many new uses in the complex field of agriculture and its related activities.

In Fig. 2 are some typical individual sources of near and far infrared and reflector equipment for use with them. It is obvious that tubular sources with cylindrical or trough-like reflectors may have advantages for some applications.

In plant growth the sun's infrared is obviously the basic source of soil heat but seems to have little to do directly with the photochemical processes of the plants, which are adapted to the wavelength range which happens to be visible, as will be discussed later.

The value of ultraviolet energy in farm practice has been recently and repeatedly pointed out. It is of interest for its effects on plant growth and on animal health, for its production of sterilization and of fluorescence. A discussion of the production and value of human erythema and tan by sunlight and sunlamps is outside the scope of this paper.

Many attempts have been made during the past twenty-five years to establish some unique value for the ultraviolet in plant growth. They have only served to show that, as in the case of the human eye, there seems to have been a close

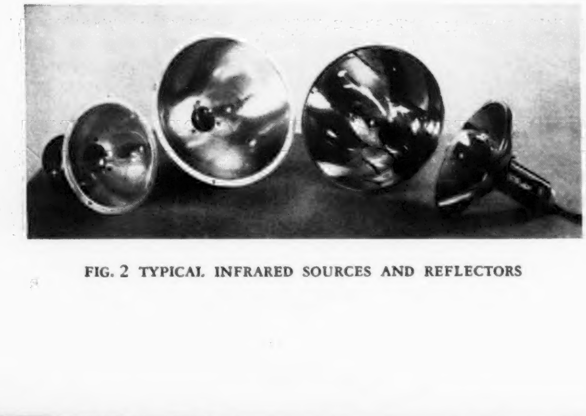

FIG. 2 TYPICAL INFRARED SOURCES AND REFLECTORS

FIG. 3 TYPICAL INSTALLATIONS OF SUNLAMPS

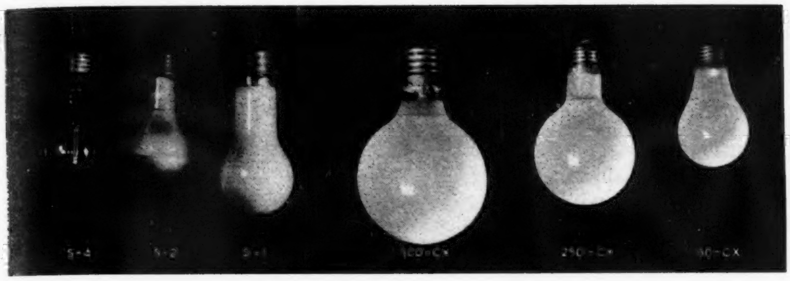

FIG. 4 STANDARD SUNLAMPS

adaptation to the energy distribution of the sun to obtain a maximum absorption and utilization. Both of these essentially photochemical actions seem to be most effectively produced by the radiant energy at the wavelength of maximum intensity in average sunlight. For this reason the radiation of an incandescent lamp needs but a slight addition of the blue and near ultraviolet to approximate sunlight, the more difficult problem being the removal of the excess of infrared. While a virtue has been made of some of this necessity by using the infrared to heat an insulated greenhouse, this does not dispose of the first effect of the infrared on the plants and this may be undesirable if there is an attempt to approximate actual sun intensities. The new fluorescent lamps with one-half of the infrared for the same watts input or one-fourth the infrared per lumen, and with a controllable amount of blue and near ultraviolet, may be just what is needed for plant growth. For a detailed discussion of use of light in plant growing, the reader should refer to articles by J. M. Arthur, L. C. Porter, and others, among the references listed at the end of this paper.

In contrast with plants, humans and animals seem to have developed a marked need and a tolerance for the ultraviolet and infrared. As is now generally known, the middle and far ultraviolet produces in certain sterols, whether in milk or fish oil, in the human skin, or an animal's fur or feathers, chemical substances having properties characteristic of vitamin D. From this comes much of the benefit of the ultraviolet in preventing and curing rickets in babies and improving the general health of adults. Similar results have been obtained by irradiating poultry, cows, and horses, as evidenced by increased egg production and hatchability, improved appearance, increased weight, and resistance to certain typical infections. It seems that in the case of cows irradiation even increases the vitamin D content of the milk, although the process is too roundabout to compete economically with either the direct feeding of irradiated yeast, the addition of vitamin D concentrate directly to the milk, or the direct irradiation of the milk itself. Fig. 3 is a composite picture showing some typical farm installations of sunlamps.

There are various standard sources of near and middle ultraviolet of the type used as sunlamps and for animal irradiation (Fig. 4). The CX types are high-temperature incandescent lamps in ultraviolet transmitting glass. Their ultraviolet component is so relatively low that they are most suitable for application where continuous or long-interval use is practical.

The application of the far ultraviolet, of wave lengths less than 2800 A (Angstrom units), result from the fact that such energy has a direct killing action on bacteria and inhibits the growth of some fungi. While there is a little radiation of this quality in direct sunlight and from some sunlamps, special sources are required for its economical production in useful amounts. Two types of mercury arc are unique in this field and, curiously enough, as mercury arcs they are as different as possible in their physical and electrical characteristics. The older type is the so-called high-pressure arc operating at about one atmosphere pressure and recently increased to as high as 75 atmospheres in the standard H6 water-cooled arc. Typical lamps of this kind are shown in Fig. 5. They operate at relatively high voltages and one to ten amperes; 840 volts and 1.4 amperes for the H6. The older direct-current quartz lamps, the original Uviarcs, have been in general use in water sterilizers, therapeutic devices, and photochemical processes for the past 25 years and recently in milk and yeast vitaminizers. The newer alternating-current lamps are, in many cases, designed for direct substitution for the direct-current arcs in field equipment. These arcs are inherently compact, high-temperature, high-pressure devices requiring fused quartz glass for their tubular enclosures. Their radiation is distributed among fifteen or more lines broadened by pressure to form an almost continuous spectrum, except for a narrow region at 2537 A, where the ionized mercury vapor absorbs the radiation.

In contrast, in every way, with these lamps the new sources of 2537 A are inherently long, low-temperature, low-pressure devices whose size prohibits the use of a quartz glass at its present cost, so that they are made of a recently developed glass transmitting one-third to one-half of the radiation at 2537 A. Typical lamps of this type are shown in Fig. 6. Their ultraviolet radiation is almost entirely in the one 2537-A line so completely absorbed in the higher pressure arcs. The remaining 5 per cent is in several lines of longer wave length. Aside from the remarkable efficiency of its production, the 2537-A energy has many unique advantages for practical use. It is about the shortest wave length transmitted by air and water and a practical glass without serious absorption. Conversely, while radiation of shorter wave length has theoretically greater lethal power, the absorption by air, water, and the organic materials in which bacteria and fungi may be suspended offsets this greater lethal power. Another objection to the shorter radiation, 2,000 to 1,850 A, such as is available from the higher pressure arcs and to some extent from the low-pressure arcs, if made of quartz glass, is that ozone, ionized air, and oxides of nitrogen may be formed in the case of air and food sterilization.

These new 2537-A lamps have recently found extensive application in the sterilization of air and of the surfaces of hospital rooms, food wrappers, and food and liquid containers. They may be of value in decreasing the bacterial count of the air in poultries and dairy barns, and in obtaining a sterile atmosphere for the storage of dairy and poultry equipment. Because of the inhibiting action on mold growth these lamps are being extensively experimented with as a means of permitting the mold-free storage of meat at temperatures 10 to 15 degrees higher than otherwise possible. The claim is for a saving in refrigeration cost, a minimization of drying and trimming losses, and a more satisfactory tenderizing. A typical installation is shown in Fig. 7. A typical air sterilization installation is the use of

planes or "screens" of ultraviolet to bacteriologically isolate babies to prevent the spread of respiratory diseases. A similar arrangement might be of value in isolating groups of fowl, rabbits, guinea pigs, and white mice to prevent the spread of their characteristic infectious diseases on farms devoted to such specialties. It is possible that the use of these lamps in schools, homes, barns, brooders, incubators, and other locations having forced air circulation, will materially reduce sickness and losses from spread of disease by airborne bacteria.

While the new fluorescent lamps are outside the arbitrary scope of this paper, they are perfectly described by its title and so closely related to the 2537-A sources as to demand discussion at this point. In the vapor space of such low-pressure mercury arcs the conversion from electrical to radiant 2537-A energy is more complete (50 per cent) than in any other practical case. A variety of recently developed fluorescent materials, such as zinc silicate and magnesium tungstate, have a comparable efficiency in the conversion of this 2537-A energy into energy having a wave length range lying generally between the limits of 4000 to 7000 A. Its energy distribution is similar to that of the sensitivity curve of the eye, so that the third conversion, in the eye, from radiant energy to light is even more efficient than the two previous steps. The final result is an efficiency two to four times that of the best incandescent lamps, depending upon the powder and color, of which there are seven standard varieties, with more in prospect. This efficiency and variety of color, with a remarkable adaptability to designed incorporation in modern types of interior and exterior architecture, as exemplified in the New York and San Francisco fairs, promises a future for these lamps far beyond anything possible in the past. Typical sizes of lamps are shown in Fig. 8.

We have referred to the new fluorescent tubular lamps in which 2537-A ultraviolet from a low-pressure mercury arc producing little light of itself is converted to visible radiation by fluorescent powders placed on the inner surface of the lamp tubes. In mercury arcs operating at higher pressures, the 2537-A radiation is largely absorbed by the mercury vapor, which then emits visible and near ultraviolet energy, much of the latter being at 3650-60 and 4047 A. These are the familiar mercury arcs used in industrial lighting. By enclosing them in bulbs or tubes of a filter glass transmitting only the near ultraviolet, an interesting source is available for the demonstration and the utilization of near ultraviolet fluorescence. A variety of materials such as zinc sulphide, rhodamine and anthracene have long been available for the conversion of 3650 to 4047-A energy into light and have been seriously considered as a way of making extended areas secondary sources of light. While adequate for stage and advertising effects, they cannot compete with the newer materials fluorescent by the more efficiently produced 2537-A energy. Except for the material of their bulbs or tubes, these lamps and their accessories are identical with the corresponding standard commercial mercury arcs. While there is near ultraviolet in sunlight and in incandescent light, the difficulty in isolating it from the visible is that there are no filter materials available which will absorb all of it and still transmit the near ultraviolet well. They all transmit some of the red so dominant in any incandescent source. The mercury spectrum is unique in having practically no red and a relatively great amount of energy in the near ultraviolet.

FIG. 5 STANDARD AIR-COOLED QUARTZ UVIARCS AND HIGH-PRESSURE WATER-COOLED CAPILLARY ARC

With these lamps in proper reflectors and projectors a wall, stage, or room may be flooded with a high intensity of practically invisible radiation. In it fluorescent materials become light sources of colors and intensities characteristic of the materials. Stage effects produced in this manner are now familiar to everyone, and similar advertising posters are just coming into use. These fluorescence-producing lamps should be interesting in connection with every phase of farm activity, as a list of their uses in other fields will suggest. They are used to identify laundry marked with an otherwise invisible ink, to determine the identity of a variety of liquid products "marked" by the manufacturer by traces of innumerable harmless fluorescent substances, and to compare samples of natural products as to identity of origin. Practically all substances are to some extent fluorescent, but this fluorescence is dependent upon such intangible conditions as to indicate very slight differences in the past history of apparently identical materials. For this reason these lamps are used in crime laboratories for the visual and photographic examination of the enormous variety of things passing through their hands, from medicines to clothing, from altered documents to restored paintings, from secretly marked money to blood stains. In medical practice, a variety of pathologic conditions are indicated by changes in the skin, hair, and teeth shown by fluorescence before they are otherwise visible.

We believe there is a still larger range of similar and entirely practical applications on the farm and in the handling of farm products. As a tentative list of interesting possibilities, we suggest the use of fluorescence in addition to the usual methods, in the sorting of potatoes, beans, fruits and berries, in the examination of the hides, hoofs, and feathers of animals for pathologic conditions especially of a fungus nature, and in the detection of molding in grain and fodder. Under these and other general headings, detailed suggestions relative to almost every phase of agricultural work might be extended indefinitely. All of them would be interesting and entertaining, some of them would certainly be of practical value.

We have described here the more important sources of radiation beyond the visible. We have suggested ways of using them for results beyond those obtained in the past. We hope that with the increasing availability of alternating current on farms, the technique of using the infrared and the ultraviolet may become a familiar part of agricultural engineering.

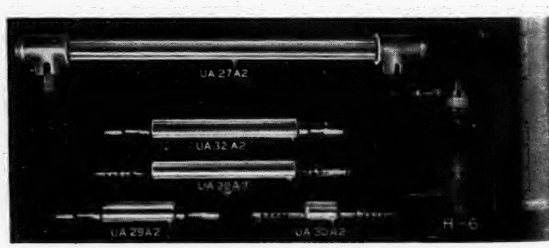

FIG. 6 STANDARD GERMICIDAL LAMPS AND STERILAMPS

FIG. 7 ONE-THIRD OF A TYPICAL GERMICIDAL LAMP INSTALLATION IN A MEAT STORAGE COOLER

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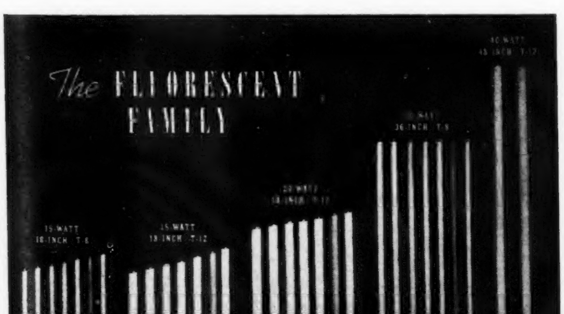

FIG. 8 MAZDA FLUORESCENT LAMPS STANDARD IN 1939

Relationship of Agricultural Engineering to Flood Control

(Continued from page 176)

than our ability to analyze it and publish results based on the findings. Bringing up to date such data is of prior importance, and it is proper that agricultural engineering research give serious consideration to the acceleration of publication of research findings through more intensely organized activity in all fields.

The most acute lack of data and conclusions occurs in the fields of hydrology and the evaluation of land-use adjustments in terms of silt control. The definite relationship between agricultural engineering and the flood control problem will in most instances be expressed in these two fields of study and then translated into economic terms.

Many agricultural engineers in the field are currently confronted with the determination of time-area-depth relations of precipitations over large and small areas, determination of infiltration capacities of soils, determination of rates and magnitude of runoff from large and small areas, and the determination of the rates and magnitude of silt transportation and deposition.

Aid from research is urgently needed in these and other related fields. It is hoped research can meet this challenge and opportunity, and that other divisions of agricultural engineering will work shoulder to shoulder with research.

The success of watershed improvement works is, in the last analysis, dependent upon wholehearted and intelligent participation by farmers, nonagricultural interests, public agencies, and science. Only through comprehensive and well-conceived education can such cooperative participation finally be gained. Here is a real challenge for agricultural engineering: To maintain and further develop its vital part in the development of agriculture's relationship to the broad watershed concept of land and water economy.

It is of course unreasonable to expect the agricultural engineer to be a superhuman individual who can develop a technical knowledge encompassing all of the complex fields discussed in this paper. We can, however, expect him to be alert to the significant interrelation between the technical and human problems involved. We might also help future agricultural engineers to meet the challenge by a better correlation of technical courses in the colleges and by a more intimate interchange of practical technical knowledge and experience between colleges and practicing engineers through the medium of the Society and its committees.

A suggestion of the future relationship between agricultural conservation and the flood control problem was made recently by the Secretary of Agriculture in an address at the annual meeting of the Association of Land Grant Colleges and Universities. The Secretary said: "The land phase of flood control might, in the long run, prove to be our most complete and extensive conservation effort."

Portable Drag-Type Sprinkler Unit for Orchards

By J. E. Christiansen
MEMBER A.S.A.E.

A LIGHT-WEIGHT portable drag-type sprinkler unit has been developed recently for the University of California experimental orchard at Paradise, California. As shown in Fig. 1, it consists of a line of ¾-in type M copper tubing connected permanently together with solder fittings.

This hard-temper tubing, a relatively new product, is available in all standard pipe sizes from ¼-in to 12-in diameters. Its rigidity and its light weight, together with its natural resistance to corrosion, make it ideal for portable sprinkler units. The ¾-in tubing has a wall thickness of 0.032 in and weighs only 0.328 lb per ft. All sizes come with outside diameters ⅛ in greater than the nominal size; thus ¾-in tubing is ⅞-in O.D. and 0.811-in I.D.

The Paradise unit consists of 120 ft of tubing, with seven sprinklers 20 ft apart mounted on ½x6-in copper-tube risers. It is connected to hydrants on the stationary supply line with a 25-ft length of ¾-in hose. The risers are held in a vertical position by a wooden cross arm (at the head end), which can be readily adjusted to keep them vertical regardless of the cross slope. Brass screws with wing nuts should be used in the cross arm, as iron bolts will rust quickly under the sprinklers. The unit is designed to be operated on a 12-hr basis and to be moved each night and morning. The sprinklers have a capacity of about 1.4 gpm (gallons per minute) at 20-lb pressure, which provides an average application of about 4 in in a 12-hr period with sprinklers spaced 20 ft apart.

The operator moves the unit from one position to another by dragging it forward, holding the sprinklers in a vertical position with the cross arm. With a main supply line every 140 ft, the hose can be left attached to the unit. Each move would then consist of shutting off the hydrant, disconnecting the hose, dragging the unit forward, attaching the hose to the next hydrant, and turning on the water.

The supply line can be spaced twice the length of the unit, however, in which case the hose would have to be alternated from one end of the unit to the other. For this purpose, each end of the copper-tube unit should be equipped with a swivel hose connection, and one end plugged, to eliminate the necessity of exchanging the positions of the hose connection and the pipe cap for each move. A plug for the hose connection can be made from a hose-to-pipe adapter and a pipe cap. One extra plug will simplify the moving. Each move would then consist of the following operations, starting with the hose attached to the head end: The hydrant would be shut off, and the hose connection stopped with the extra plug. Returning to the rear end, the operator would remove the plug, attach the hose, and turn on the water. For the next move he would turn off the hydrant, disconnect the hose at both its ends, plug the hose connection, and drag or carry the hose forward to the head end of the unit, where he would remove the plug, attach the hose, drag the complete unit forward to the next hydrant and attach it.

When the unit has completed the last setting in a row, it is moved to the next row as a freight train is switched from one track to a parallel track. The cross arm would be removed, and the unit switched back into the next tree row and then dragged forward again for the first setting. For alternate middle irrigation it would be switched over two tree rows. The tubing, being quite flexible, can be dragged around a curve without injury. If bent too sharply, however, it will kink. Care must be exercised, in moving from one row to another, to keep sprinklers from catching on the trees.

Although the unit is easily moved from one tree row to another in a deciduous orchard, difficulty might be encountered in a citrus grove because of the low limbs. This could be overcome, however, by using standard pipe nipples for risers so that the risers and sprinklers could be removed before a change from one tree row to another. The use of tee fittings with side outlet threaded for standard pipe would also eliminate the need for special couplings at the top of the risers.

For winter storage the unit can be placed beside a fence, where it will be out of the way and protected from damage. Since the entire unit is of copper and brass, it will not corrode.

Copper tubing for portable sprinkler systems was suggested by William Weston of La Mesa, who has used it the past two seasons. It weighs less and has a higher permanent carrying capacity than steel tubing. It requires no special protective coatings such as galvanizing, which adds materially to the cost of systems using steel. This type of system has the further advantage of eliminating the need of quick couplings. It is therefore less expensive than most other portable orchard systems. The complete unit, with seven sprinklers and 25 ft of hose, cost about $28.50. The expense per acre would depend *(Continued on page 186)*

The author is assistant irrigation engineer, University of California.

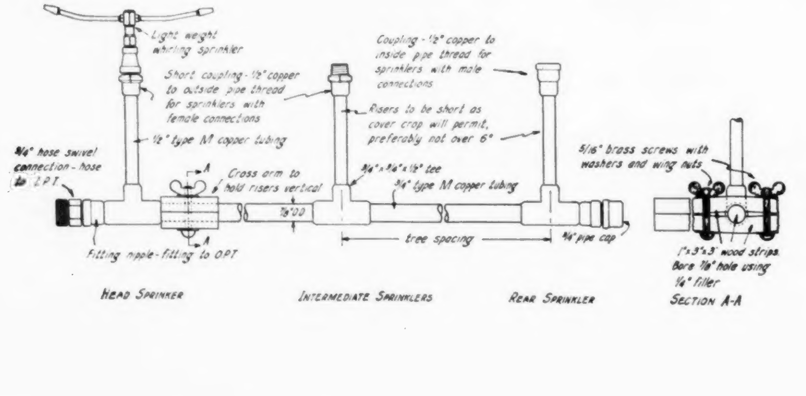

FIG. 1 DETAILS OF PORTABLE DRAG-TYPE SPRINKLER UNIT, SHOWING ALTERNATE TYPES OF RISERS

Transport Wheels for Agricultural Machines

VII. Relative Effects of Steel Wheels and Pneumatic Tires on Agricultural Soils

By Eugene G. McKibben and Robert L. Green
FELLOW A.S.A.E. JUNIOR MEMBER A.S.A.E.

SUMMARY

1 The movement of soil particles under the actions of a 6x28-in steel wheel and a 6.00-16-in pneumatic tire were studied by means of beads accurately placed in a soil box (Figs. 2 and 3).

2 The motion of soil particles was found to be curvilinear in both cases, but greater and more complex under the steel wheel.

3 The action of these transport wheels resulted in both an expanding and a compacting effect. This was particularly true for the steel wheel.

4 These counter effects coupled with the curvilinear motion of individual soil particles make it very difficult to appraise the physical, much less the agronomic effects of the passage of a transport wheel.

5 The pneumatic tire damaged temporary field roads much less, especially where a low inflation pressure was used.

6 Only about one-fifth as much soil adhered to the pneumatic tire during operation on a wet, sticky, soybean stubble field.

FROM the agronomic standpoint the transport wheel may well be thought of as a necessary evil. An agricultural soil in a good state of tilth is a poor road surface, and in most cases it is damaged, at least temporarily, by the passage of a transport wheel. The accurate quantitative determination of the extent of such damage is a difficult and complicated problem which has not been satisfactorily solved. The results reported in this paper admittedly barely scratch the surface.

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The authors are, respectively, associate professor of agricultural engineering and research fellow in agricultural engineering, Iowa State College. (The latter is now assistant soil conservationist, Soil Conservation Service, U. S. Department of Agriculture.)

Movement of Soil Particles. A knowledge of the character of the motion of soil particles under the action of transport wheels would seem to be fundamental to an understanding of the effects of such wheels on agricultural soils. A qualitative study of this phase of the problem was made by use of the soil box and apparatus shown in Fig. 2.

Des Moines molding sand was selected for these studies because, of those materials available, it seemed to have the best combination of laboratory workability and "field soil" physical characteristics. The plasticity constants for this soil are given in Table 1 and its grain size distribution is shown in Fig. 4.

The moisture content used was 6 per cent on the dry basis. This moisture content was the lowest at which the sand could be squeezed into a ball with the hand. By the use of a method of moisture determination developed by Bouyoucos[1] it was possible to keep the moisture content within 0.5 per cent of the value selected.

The sand was placed in the box in layers of a thickness which compacted to 0.2 ft when subjected to a pressure of 300 lb per sq ft. Small beads arranged according to a predetermined color pattern were placed accurately at the corners of 0.2-ft squares on the surface of each layer of sand by means of a plywood template and their position carefully determined and recorded by means of measuring devices working from reference surfaces on the upper edges of the soil box.

The steel wheel and pneumatic tire shown in Fig. 1 were then rolled across the sand surface under the load selected. The apparatus used for this purpose recorded the rolling resistance and effective rolling circumference. The individual beads were then located by means of a small trowel and a vacuum cleaner, and their new position carefully determined by the method previously mentioned. After an exploratory trial with the steel wheel at a 500-lb load, three pairs of trials were run at 500, 1000, and 1000-lb loads and 20, 22, and 15-lb inflation pressures, respectively.

[1]G. J. Bouyoucos. A field outfit for determining the moisture contents of soils. Soil Science 46:107-111. 1938.

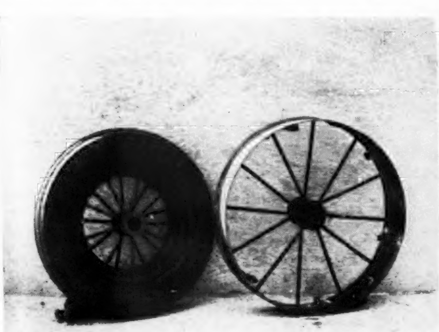
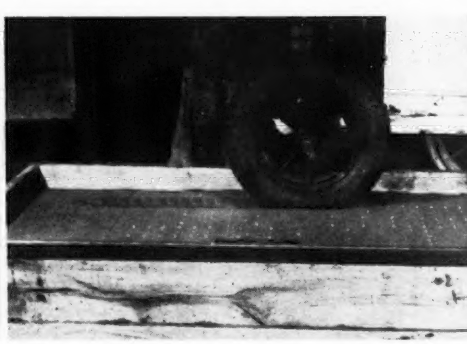




Fig. 1 (Left) Four-ply, 6.00-16-in pneumatic implement tire and 6x28-in steel wheel used to obtain the data shown in Figs. 5 to 7. Fig. 2 (Center) Apparatus used to obtain the data shown in Figs. 5 to 7. Note the pattern of beads used to determine the relative movement of soil particles. This pattern was repeated seven times at increasing depths of 0.2 ft. Fig. 3 (Right) Track made by a 6x28-in steel wheel. The cracks perpendicular to the direction of travel, typical for transport wheels operating in friable soil, are evidence of wheel slippage

TABLE 1. CHARACTERISTICS OF DES MOINES MOLDING SAND USED IN APPARATUS SHOWN IN FIG. 3

Texture	Sandy loam
Lower liquid limit[a]	20
Lower plastic limit[a]	16
Plastic index[a]	4
Moisture[b], per cent	6

[a]American Association of State Highway Officials. Standard specifications for highway materials and methods of sampling and testing, p. 221-243. The Association, Washington. 1935.

[b]At time of tests; calculated on the dry basis.

Since the results were similar in all cases and the charts needed for complete presentation would require an excessive amount of space, only the data for the last pair of trials are given. In this trial the pneumatic tire was inflated to 15 lb per sq in and a 1000-lb load was used on both wheels. The rolling resistances were 212 and 405 lb, respectively, for the pneumatic tire and steel wheel. The effective radii were 13.5 and 20.8 in, respectively, indicating a slippage of 11 and 48 per cent when compared with the stationary loaded radii of 12.2 and 14 in.

The track shown in Fig. 3 indicates the type of stresses which a rolling transport wheel imposes on the surface of a friable soil. Note the cracks across the track perpendicular to the direction of motion and those starting at the edge of the track and having an angle of approximately 45 deg.

A side view of the movement of the soil particles in the extended center planes of the wheels is shown in Fig. 5. Not only is the forward and downward movement much greater under the action of the steel wheel, but in front of this wheel those soil particles near the surface have an initial upward displacement.

A similar view of the movement of the soil particles in planes 0.2 ft to one side of the extended center planes of the wheels is shown in Fig. 6.

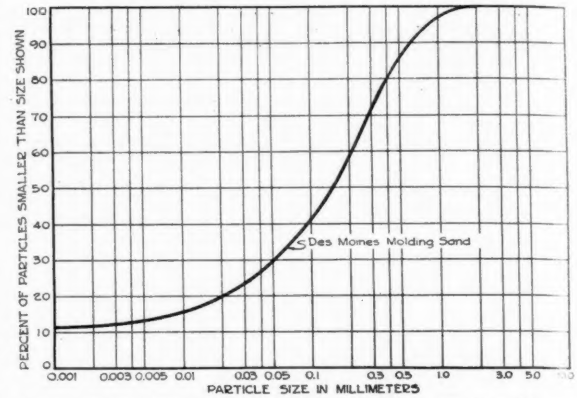
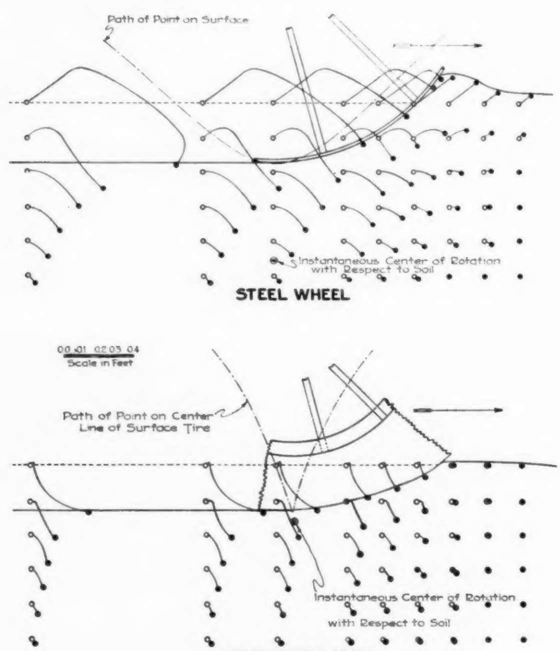


Fig. 4 Grain diameter accumulation curves for the Des Moines molding sand used in the apparatus shown in Figs. 2 and 3, and to obtain the data of Figs. 5 to 7. Other characteristics of this sand are given in Table 1

The movement of soil particles in planes perpendicular to the direction of travel is shown in Fig. 7. Part I of this figure shows the positions of soil particles just ahead of the wheel compared with their undisturbed position. Part II gives the same comparison between the undisturbed positions of soil particles and their final positions after the wheels have passed. The numbers represent the cross-sectional areas as per cent of the original undisturbed areas.

Ahead of the wheel and to the side of track after the wheel has passed there is an increase in cross-sectional areas (expansion). This increase is particularly marked in the case of the steel wheel. Below the wheel tracks there is a marked decrease in cross-sectional areas (compression). This compressed area widens as the depth increases. These counter effects of expansion and compression, coupled with



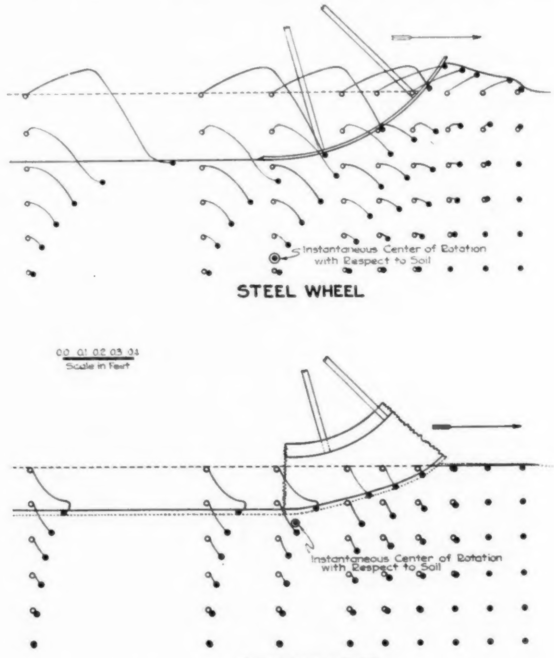


Fig. 5 (Left) Movement of soil particles in the center planes, extended, of a 6x28-in steel wheel and a 6.00-16-in pneumatic tire, when carrying a 1000-lb load in Des Moines molding sand. Fig. 6 (Right) Movement of soil particles in planes 0.2 ft to one side of the extended center planes of a 6x28-in steel wheel and a 6.00-16-in pneumatic tire when carrying a 1000-lb load on Des Moines molding sand

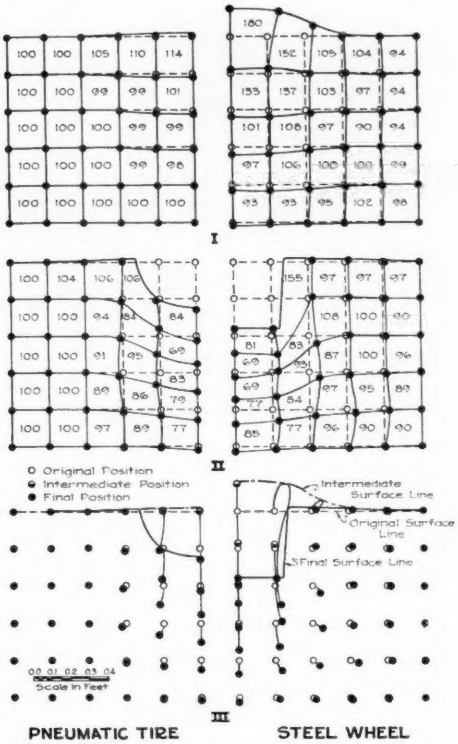


Fig. 7 Movement of soil particles in planes perpendicular to the direction of travel of a 6.00-16-in pneumatic tire and a 6x28-in steel wheel when carrying a 1000-lb load on Des Moines molding sand: (I) Effects just ahead of wheels, numbers indicate per cent of original volume; (II) effects after wheels had passed; (III) paths taken by individual particles

the curvilinear motion by which these effects are obtained, make an accurate appraisal of the net effect of transport wheels a difficult if not an impossible task.

The paths taken by individual soil particles under the action of these transport wheels are shown by Part III of Fig. 7.

Damage to Field Roads. In order to obtain some specific data on the relative damage to field roads, a 6x28-in steel wheel and a 6.00-16-in four-ply pneumatic tire were mounted on a wide-tread cart as shown in Fig. 8. This cart was loaded with cast iron so that each wheel carried 1000 lb, and was operated on bluegrass sod, soybean stubble, and winter rye.

The results obtained are given in Table 2. In all but

Fig. 8 Studying the relative effects of a 6x28-in steel wheel and a 6.00-16-in pneumatic tire on a temporary road across a soybean stubble field. Each wheel carried 1000 lb and the pneumatic tire was inflated to 20 lb per sq in

one case the recommended inflation pressure of 20 lb per sq in was used. In every instance the maximum depth of track was appreciably greater for the steel wheel. The average depth of track was also greater for the steel wheel, except in one case, third from last line of Table 2.

This particular situation is an illustration of the fact that the inflation pressure must be less than the supporting capacity of the soil if pneumatic tires are to render their maximum benefits. As shown by the next line in the table, the pneumatic tire gave relatively better results as the supporting capacity of the soil was increased by repeated runs in the same track.

The beneficial effect of reducing the inflation pressure to 10 lb per sq in, as shown by the data of the last line of Table 2, is particularly striking. These results check with other data previously published[2] and suggest the possibility that under certain conditions the advantages of low inflation pressures may well justify the cost of oversize tires or even the tire abuse which accompanies underinflation.

Adhesion of Soil to Wheels. In operating the cart shown in Fig. 8 a marked difference in the tendency for soil to adhere to the two wheels was noted. When operated on the temporary road across the soybean stubble a layer of soil 0.8 in thick accumulated on the steel wheel while only 0.1 in of soil adhered to the pneumatic tire.

As an additional test the cart was driven at random over the soybean stubble field when the freshly thawed soil was sticky. The steel wheel quickly accumulated a layer of soil and straw 1.5-in thick while the soil on the pneumatic tire never exceeded 0.3 in.

[2]Eugene G. McKibben and J. Brownlee Davidson, Transport wheels for agricultural machines. II. rolling resistance of individual wheels. AGRICULTURAL ENGINEERING 20:469-473. December 1939.

TABLE 2. RELATIVE TENDENCIES OF 6x28-IN STEEL WHEEL[a] AND 6.00-16-IN PNEUMATIC TIRE[a] TO FORM RUTS IN TEMPORARY FIELD ROADS WHEN LOADED TO 1000 LB PER WHEEL

Field	Penetrometer[b] reading, in	Pressure, lb	Speed, mph	Number of runs in same track	Average depth of track, in			Maximum depth of track, in		
					Steel	Pneumatic	Diff.	Steel	Pneumatic	Diff.
Bluegrass[c]	3.1	20	7	10	1.0	0.5	0.5	1.3	0.8	0.5
"	3.1	20	7	20	2.4	0.9	1.5	5.6	1.6	4.0
Soybean stubble[c]	5.4	20	4	1	1.3	0.9	0.4	2.0	2.0	0.9
"	5.4	20	4	5	3.3	1.5	1.8	4.6	2.1	2.5
"	5.4	20	4	10	4.7	2.3	2.4	6.1	3.1	3.0
"	4.8	20	4	25	6.6	4.2	2.4	10.5	5.8	4.7
Winter rye[c]	5.4	20	2	1	3.7	3.9	−0.2	6.4	4.5	1.9
"	5.4	20	4	5	5.2	4.9	0.3	6.4	5.6	0.8
"	6.2	10	2	1	5.0	1.4	3.6	6.9	2.1	4.7

[a]Fig. 8.
[b]Rototiller penetrometer; A. A. Stone and Ira L. Williams. Measurement of soil hardness. AGRICULTURAL ENGINEERING 20:25-26. 1939.
[c]Clarion loam.

Early American Drainage Relics

By J. R. Haswell

FELLOW A.S.A.E.

ONE of the main talking points for tile drains is their permanence. Interest in the original John Johnston tile from near Geneva, New York, was in the fact that they were made in 1835 and still are sound. The drains made with them are operating, where the outlets are open.

A few weeks ago, while on a trip with a county agent, we found a machine 75 years old that formed U-shaped tile like Johnston's. It was dismantled, but we got the die, plunger, and forks outside and photographed them. The earliest dies are shown in front of the barrel of the machine in the photograph. The rectangular piston sits on the pugged clay hopper, but the heavy crank that pushed it against the clay was left out of the picture. As the two pieces came out of the dies they were supported on the wooden forks shown in the foreground. At the end of the stroke the pieces were cut loose and placed on drying pallets. Other dies are shown on each side and four other forks are shown in the background.

At the same place a piece of heavy clay water pipe was shown as having been dug up locally. It has the date 1824 pressed on it, showing it to be 11 years older than Johnston's.

Besides these, extension relic hunters have collected iron-stone pump stocks and pipe lines, drain tile made on a potter's wheel, small drain tile with collars similar to that used by Colonel Geo. E. Waring to drain Central Park, New York City, and, of course, the two original Johnston tile supplied by B. B. Robb, of Cornell University. These items will be on exhibit during the annual meeting of the American Society of Agricultural Engineers at Pennsylvania State College, June 17-20.

(TOP) U-SHAPED CLAY TILE DATED 1824. (BOTTOM) PARTS OF A 75-YEAR OLD TILE MAKING MACHINE

The author is head of the department of agricultural engineering extension, Pennsylvania State College.

Portable Drag-Type Sprinkler for Orchards

(Continued from page 182)

upon the required frequency of irrigation. A unit of this size, moved twice a day, would cover about 3.85 acres in 30 days. The cost of the stationary pipe system for distributing water to the portable units will generally exceed the cost of the portable units. The supply pipe lines can be spaced farther apart, however, than for systems using undertree sprinklers connected together with garden hose.

Field tests were made to determine the friction losses in the tubing and hose, together with the pull required for dragging the unit. The friction loss between the first and last sprinkler was 12.6 ft, with an average pressure of 37 lb per sq in and with an average sprinkler discharge of 1.9 gpm. The equivalent loss for an operating pressure of 20 lb per sq in at the last sprinkler would be only 7 ft, or 3 lb. These friction losses correspond to a friction factor, f, Weisbach formula, of 0.021, a very low value for pipe of this size. The loss in the hose was 22.7 ft, or 9.8 lb, and corresponds to a friction factor of 0.036.

The pull required to drag the unit, complete with the hose, on wet ground was about 50 lb, in a test made on a slight upgrade.

AUTHOR'S NOTE: The author acknowledges the assistance of Dr. O. Lilleland of the pomology division, University of California, and of Mr. J. A. Ream of Paradise, in developing this sprinkler unit.

FIG. 2 (LEFT) SPRINKLER UNIT IN OPERATION. FIG. 3 (RIGHT) HEAD SPRINKLER ON LINE, SHOWING CROSS ARM TO HOLD SPRINKLERS VERTICAL

A Tractor Drawbar Loading Machine and Dynamometer

By E. L. Barger

MEMBER A.S.A.E.

THE tractor drawbar loading machine and dynamometer described in this article was built at Kansas State College in 1937. It has been used two years in teaching and research work in farm power. Of the relatively few tractor drawbar testing machines found in colleges and industry, no two are alike, and this one is no exception. It embodies no new principles, but some of the old principles have been given new application.

Equipment of this type is valuable in teaching some phases of farm power, particularly to engineering students. It serves a need in the farm power laboratory comparable to strength-testing equipment in the materials laboratory, and makes possible the application of engineering technology to problems in the field.

Probably tractor drawbar loading and testing equipment could be used more widely in agricultural engineering laboratories. The high cost of such equipment and the shortage of information on its design and construction have, no doubt, been retarding influences. Since, at present, this equipment must be custom built in the laboratory or shop, descriptions of the equipment which has already been built and proved to be satisfactory would be of value to anyone contemplating the construction of such a machine.

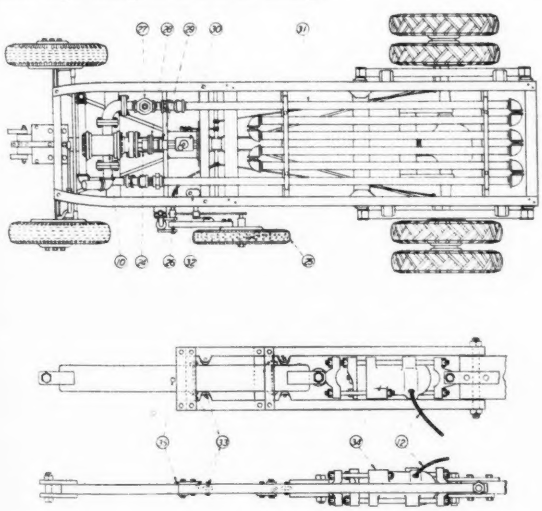
Contribution No. 93 of the agricultural engineering department, Kansas State College. The author is associate professor of agricultural engineering, Kansas State College.

General requirements used as a basis for this design and the characteristics desired in the finished machine specified that it should cost not more than $1000 for materials, instruments, and equipment; provide capacity to handle tractors up to and including four-plow sizes, with up to 6000 lb drawbar pull; be capable of operation at speeds up to 20 mph (miles per hour); be suitable for student field laboratory instruction with room for a class of twelve students to ride, observe, and take data; incorporate both direct-reading and recording instruments for draft and speed; and be suitable for research work in farm power.

The machine was built on the chassis of a used Ford V-8 truck. Slight alterations in the frame were made as shown in Fig. 1.

Loading and load control are accomplished by throttling the discharge of a gear type pump (10)*, pumping S.A.E. 40 oil, and driven through the conventional truck transmission. After the oil passes the throttle valve (27) it circulates through a cooling coil (31) and returns to the supply reservoir (9) from which it flows back to the pump. The draft or drawbar pull of the machine, caused by the resisting torque of the loading pump transmitted to the rear wheels, is carried through a telescoping tongue (Fig. 1) and hydraulic dynamometer cylinder (34) to the front end

*Numbers in parenthesis refer to the parts numbered in Figs. 1 and 2.



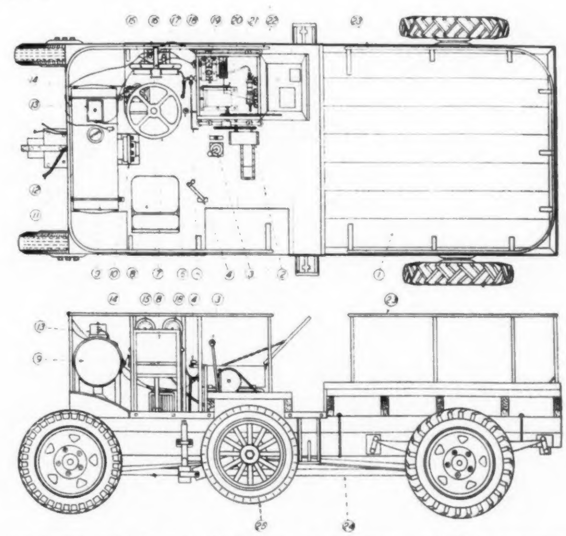


Fig. 1 (Upper left) Chassis of the loading machine, showing the loading pump, cooling coil, fifth-wheel arrangement, and other construction features. (Lower left) The telescoping tongue showing the use of guide rollers permitting free transmission of the draft to the dynamometer cylinder which is placed near the loading machine. Fig. 2 (Right) Top and side views of the assembled machine. Parts, as numbered are (1) weight deck, (2) speedometer and chart drive gear box, (3) transmission gear shift lever, (4) fifth-wheel lifting crank, (5) oil pressure cut-off valve to recording unit, (6) signal horn button, (7) loading valve control wheel, (8) operator's seat, (9) oil reservoir, (10) gear pump, (11) switch, start-stop needle, and timer, (12) flexible oil conduit, (13) electric counters for tractor wheel slip, (14) tractor engine speed indicator, (15) loading pump pressure gage, (16) battery, (17) speedometer, (18) direct-reading draft gage, (19) electrically controlled stop-watch, (20) start-stop needle and solenoid, (21) strip chart drive mechanism, (22) pressure indicator mechanism, (23) guard rail, (24) draft coupling to rear axle, (25) fifth wheel, (26) flexible shaft, (27) throttle or loading valve, (28) flexible coupling, (29) outboard bearing front transmission shaft, (30) truck transmission, (31) pipe coil, (32) fifth-wheel lifting mechanism, (33) guide rollers, (34) dynamometer cylinder, and (35) stop pin

of a draft coupling (24). The draft is transmitted through the draft coupling directly to the rear truck axle housing.

Hydraulic instruments are used to measure the draft. A direct-reading draft gage (18) is mounted on the instrument panel in front of the operator, to use in adjusting the load control valve to any desired loading. This direct-reading gage is also desirable for use with students in the nontechnical power courses, since recording instruments are not easily understood by them. The oil pressure from the dynamometer cylinder is also carried to a recording unit which consists of a pressure indicator mechanism (22) and a standard strip-chart drive mechanism (21). The chart is driven through a flexible shaft (26) from a fifth wheel (25). By means of proper calibration factors, draft is calculated from the chart records. A stop watch operated electrically (19) in unison with a solenoid actuated needle (20) which records the beginning and end of a test, gives time and distance, the remaining data necessary for power measurement. A speedometer (17) is also mounted on the instrument panel, from which the speed may be read direct. It is driven from the fifth wheel at ten times normal speed, through a special gear box (2). The gear box also acts as a terminus for the flexible shaft and a support for the sprocket which drives the recording instrument.

Tractor drivewheel slippage is measured with electric counters (13) operated by contactors on each drivewheel. The contactors are auto distributors equipped with 10-face cams. Dustproof aluminum cover plates replace the regular distributor head, and the regular condensors are used across the breaker points. The performance of these units has been highly satisfactory.

DESIGN AND PERFORMANCE DATA

There are many problems in the design of apparatus of this type, and some of them are difficult to answer unless performance characteristics are available on similar machines which are in use and giving satisfactory results. The remainder of this paper presents design and performance data which have been found to apply in this case.

The tractive coefficient for the dual tires (drawbar pull divided by total weight on rear wheels, at a rate of slippage still permitting smooth operation and satisfactory control of the unit) has been found to vary from 0.6 to 0.8, depending on the traction surface. A suitable draft-weight factor may be taken as 0.7 for a basis of computing auxiliary weight. Cast iron weights are used on this machine. Heavy duty truck chains are also available when traction conditions demand their use.

Transmission, pump, and traction efficiencies, if known, will aid in selecting the loading pump and in designing the radiation system for heat dissipation. The overall efficiency of this loading unit has been found to vary from zero to 40 per cent, depending upon the load being absorbed and the condition of the surface on which the equipment is operated. In calculating the efficiency, the work input is considered as that at the tractor drawbar and the output is that represented by the oil discharge work ($P \times V$) of the pump. The 40 per cent value was obtained when operating on a hard road surface and would approach a maximum efficiency which is the basis for calculation.

Under normal conditions of pump operating speed and loading, the type of pump used in this unit has a maximum efficiency of about 75 per cent. Since the loading pump losses as well as the ($P \times V$) discharge work go to raise the temperature of the oil, approximately 50 per cent of the energy will be absorbed by the oil as heat which must be dissipated. With any given loading and air temperature, equilibrium temperatures will be reached in the energy dissipation system, and it is desirable to hold their temperatures at a reasonable figure. Since the oil reservoir is located near the operator's seat in this design, it would not be desirable for the oil temperature in the reservoir to exceed 150 F (degrees Fahrenheit). Approximately 56 sq ft of cooling surface provided by 54 ft of 2-in pipe, the pump, and the oil reservoir, have been found adequate to hold the temperature under this figure.

LOADING PUMP OPERATING CHARACTERISTICS

The loading pump used is a straight spur gear type with 2-in intake and discharge. It has a maximum recommended speed of 600 rpm, 1000 lb per sq in maximum working pressure, and a 60-gpm (gallons per minute) capacity at zero head and 600 rpm. The pump drive shaft is $1\frac{1}{2}$ in in diameter.

With a ratio of 33 to 1 between the front end shaft of the transmission and rear wheels, when in the low gear of the truck transmission (highest pump speed), a pump speed of 690 rpm may be had at 2 mph. On a basis of 6000 lb drawbar pull at 2 mph, with the efficiencies given above, the torque to the pump shaft at 690 rpm would be 130 lb, which is within the capacity of the truck transmission. The pump shaft and flexible coupling must be able to handle this torque.

As regards maximum pump pressures and capacity, a combination of the two is needed which will permit proper range of loading. If a 500-lb pressure is assumed (500 lb per sq in is considered the operating maximum for this machine), then on a basis of 6000 lb draft at 2 mph with the efficiencies given above, a discharge of 44 gpm is required. Obviously pump speeds must be kept up by proper selection of gears in the truck transmission, if pressures and pump shaft torque are to be held to a safe value for any given drawbar loading and ground travel speed.

The loading or throttle valve used is an extra heavy duty 2-in globe valve.

No consideration was given to automatic load control in the design of the apparatus. An operator is required at all times. A load control wheel and a direct-reading draft gage are located conveniently before the operator. Load response to the control valve is positive and quick, and the performance has been satisfactory.

The accuracy with which power is measured with any equipment of this type depends primarily on the accuracy of calibration of the various instruments. The fifth wheel or distance measuring wheel was calibrated by rolling it over several different surfaces and measuring its effective rolling circumference, keeping the tire inflation pressure constant. Since the fifth wheel follows the track smoothed out by the front truck wheel, distance measurement may be expected to be within one per cent of the correct.

Three methods of checking the draft-measuring instruments were employed. The hydraulic dynamometer gage and pressure indicator mechanism used for recording the draft were calibrated first on a regular Crosby gage tester. The second calibration was by loading the dynamometer cylinder with known weights, and the third check was made by placing the unit in series with another dynamometer of known calibration and comparing results of field tests.

The pressure indicator mechanism used to record draft is equipped with six springs of different capacities to give significant deflections under a wide range of loadings. Data were obtained in the second calibration to construct for each spring calibration curves of total load versus needle deflection. The slope of this curve is the calibration factor for the spring, and it is imperative that the slope be uniform throughout the range of loading if accurate results are to be obtained from the recording unit.

Low-Cost Housing in Rural Areas

By Deane G. Carter
FELLOW A.S.A.E.

THE PURPOSE of this paper is to outline the problem of low-cost housing for rural areas. Factors involved in the approach include (1) a consideration of the existing conditions, (2) the economic status of the families concerned, (3) the present costs for housing, (4) the delineation of the objectives and meaning of low-cost housing, (5) a recognition of the obstacles affecting the solution, and (6) proposals that offer some prospect for the achievement of the objectives.

Since the beginning of the present century, definite attention has been given to the improvement of conditions of housing for low-income families. Among the activities, the most important include the New York housing or "tenement" laws, the development in workingmen's homes during the World War period, the enforcement of municipal and sanitary regulations in cities, the educational and research developments affecting housing, and the great technical progress in materials, construction, and equipment. These developments have undoubtedly resulted in definite contributions to living conditions and facilities. The net result, however, has been to increase the capital cost of housing per family unit. Most of the industrial efforts, such as factory production, standardization of units, packaged or complete items, and improvement of materials—in themselves efficient and economical—in total, do not reduce the cost of housing, but tend rather to increase costs by creating additional demands, and stimulating the desire for the newest facilities.

INCREASED SPREAD IN QUALITY OF HOUSING

Edith Elmer Wood[1]* concludes from a survey of housing over a 14-yr period (1916-1930) that "the net result of accomplishment is hardly one to justify a high degree of optimism. ....For the top economic third, housing standards have undoubtedly risen................. This is what responsible Americans presumably mean when they talk about our housing standards being the highest in the world................. So far as the other two-thirds.................are concerned,................. we have lost ground."

More recently, the committee reports from the President's Conference on Home Building and Home Ownership[2], together with the reports from various research agencies[3], and the Farm Housing Survey[4], have brought together valuable data emphasizing the economic aspects of housing.

One is forced to the conclusion that very little has been done to reduce the cost of housing in any appreciable amount, and that attention to the farm house has been meager indeed. It may be well, therefore, to examine the subject of low-cost rural housing somewhat in detail.

The fact of housing need is so obvious that little space need be given to discussion. The general thought has been expressed by the statement that "one-third of the nation is ill-housed." The Farm Housing Survey reveals a farm dwelling condition far below the so-called "acceptable" standards. The "index" of structural condition, based upon the United States average, is 44, which indicates roughly a condition of structural repair or adequacy of 44 on a scale of 100. Other data indicated the following facts relative to the total number of houses surveyed:

1 35 per cent were unpainted frame
2 41.5 per cent were without clothes closets
3 80 per cent did not have electricity in the home
4 85 per cent were over 10 years old
5 85.5 per cent were without bathrooms
6 91.4 per cent were without central heating systems
7 95.5 per cent did not have septic tank sewage disposal.

The foregoing data are for the entire nation. In many regions, states, and communities, the condition is far less adequate than is indicated by the general average. There is no means of indicating the less tangible qualities of work facility, mechanical equipment, comfort, or sufficiency of space. Studies at the Arkansas station[5], however, emphasize the deficiencies of housing at the lower cost levels.

FARM INCOME AND THE $300 TO $2500 HOUSE

In terms of dollar value, the farm house stands relatively low, with an average census valuation of about $1,200 per farm. In Arkansas the average house value is $390, and in certain counties where there is a combination of a high proportion of tenant-occupants and low farm values, the dwelling value averaged $330[6].

The average annual gross income per farm in the United States, for the 10-yr period 1925-34, was about $1,350, and somewhat less in 1935 and 1936. If only the expenses for wages, feed, fertilizer, and motor-vehicle operation are subtracted from the gross income, the average income would be about $1000 per year. From this amount the farm operator must meet the costs for taxes, interest, capital expense, and living. The median income is doubtless lower than the average, and more than one-half of the 6,700,000 farm families have "salary" incomes of less than $1000 per year.

If it might be assumed that the dwelling cost should not exceed two and one-half times the annual salary, the average maximum expenditure for dwellings would be indicated as $2,500. If it could be assumed further that the replacement cost of existing houses is double the present value, the average indicated would approximate $2,500 as the dwelling cost[7]. This definitely places the farm house in the low-cost group on the basis of average figures. For many thousands of cases, $2,500 is far beyond the financial capacity of the farmer.

In contrast with the very definite limits of income and housing value on farms, the prevailing practice in construction is at a very much higher level. Some authorities frankly state that it is impossible to build an adequate house for less than $3,000[8].

In 36 cities in 1929, only 5.6 per cent of the single-family dwellings cost less than $2,840, and the largest group, constituting 22.8 per cent of the total, were in the cost range of $5,680 to $7,099[9]. In 85 American cities in 1929 the average cost of single-family dwellings was $4,902, "and the selling price was certainly 30 per cent higher"[10].

Presented before the Farm Structures Division at the fall meeting of the American Society of Agricultural Engineers, at Chicago, Ill., December 5, 1939. Approved as Research paper No. 660, Journal Series, University of Arkansas. The author is professor and head of the department of agricultural engineering, University of Arkansas.

*Superscript figures refer to references cited at the end of this paper.

The Purdue University housing research project was conducted with the objective of "attempting to assume the position of the average home owner", and to develop housing at costs not to exceed $5000 (in 1936)[11].

A prominent authority[9] dealing with the subject of existing economic demand for small dwellings states that "................ of the total number of families living in housing estimated to have an average investment value of $1200, 37 per cent live in single-family dwellings. What sort of houses these are is not known. It is assumed that they must either be small 'shacks' on unimproved streets, or very old and very much depreciated houses, originally built for a higher income class."

It is evident, therefore, that there is a wide gap between the normal capital costs of construction, and the ability of the average family to pay for adequate housing. Low-cost housing is the only possible solution.

In the light of the rural conditions that exist, it is indicated that low-cost housing must come within a cost range at or below $2,500, with a median of around $1,250. No doubt a closer analysis of the problem would suggest the desirability of several "degrees" of cost or quality, at levels of $500, $750, and up to $2,500, or possibly $3,000.

Dollar values are not adequate to define low-cost housing, however, because of the variations that occur throughout the country, in location, materials, farming types, climate, and other factors. It must be agreed, however, that low-cost housing should be defined as housing at a level of cost and quality that will provide reasonably satisfactory facilities for living, and be within the financial capacity of families in the lower half of the income scale.

The fundamental objective of any program must be to assure housing, consistent with basic needs and social standards, that is within the means of low-income families, at the lowest possible cost to the occupant.

If the various programs in housing are examined, it will be found that a variety of objectives, other than low cost, have been allowed to dominate.

LOW-COST HOUSING AND OTHER OBJECTIVES

Space does not permit a detailed analysis of the various programs; however, the primary objectives that have motivated most of the activities are included in the following list:

1 To eliminate blighted areas in cities
2 To provide employment for workers in the construction industries
3 To increase the production of capital goods
4 To put idle money to work
5 To make available insured forms of investment
6 To achieve a higher standard of construction
7 To promote the use of certain kinds of materials, or methods of construction, or quality of workmanship
8 To decrease the cost and complexity of financing by extending the amortization period of loans, decreasing interest rates and increasing the ratio of the loan to appraised value.

There is no question as to the value or the worthiness of each of these objectives. Most of them, however, apply to urban rather than rural situations, and only one (decreasing the financing cost) has been effective in cost reduction to the owner. As a matter of fact, a majority of the programs thus far have tended to increase rather than decrease costs, either by the regulations enforced, or increases in quality requirements. It is the judgment of the author that no important measure of success in low-cost housing has been achieved as a result of these programs.

It was noted in the foregoing discussion that various housing objectives (either stated or implied) have tended to digress from the central objective of low-cost housing. There are some further obstacles, somewhat intangible, that appear to be largely mental rather than actual, as follows:

1 There is a tendency to visualize housing at a $5,000 standard of quality, and specifications, magazine articles, and other publications are scaled to a high quality of design, structure, and workmanship.

2 Housing facilities are gauged by an arbitrary or an ideal standard, rather than in relation to existing conditions.

3 The approach to the subject is largely conventional, that is, the assumption is made that material qualities must conform to typical specifications; that wage scales must be maintained; and that available mechanical equipment must be installed.

4 The assumption is made that each house must be planned as an individual unit, according to the requirements set up by the owner, and adapted to the size of the family that is to occupy the house.

Workers in the field of agriculture are confronted with the facts of need, low income, and economic necessity that require low-cost housing. Irrespective of the desirability of high qualities of construction, high quality of workmanship, adequate size, modern equipment facilities, and values derived from the newer materials, the fact remains that low cost can be obtained only by some sacrifice of these characteristics. If this fact is ignored, farm families will of necessity shift for themselves in plan, structure, and quality of housing.

OPPORTUNITIES FOR REDUCING COST OF FARM HOUSING

At this time there appear to be four procedures that offer some possibilities for definite reductions in the cost of housing in rural areas, namely, (1) planning, (2) reduction in qualities, (3) the contribution of noncash resources, and (4) a more adequate financing arrangement.

Planning is assumed to include all studies and analyses involved in developing housing at lower costs. Housing costs are divided broadly between materials costs and labor. Planning must include analyses of operations, processes, selection of materials, efficiency methods, and the like that will result in specific savings to the owner. Housing values consist essentially of size, quality of structure, and equipment installations. Planning, therefore, involves a competent study of the use of space, the efficient layout of areas, the elimination of waste, the materials requirements, and equipment minimums. The planning phase must be carried to the point of acceptance by the occupant, of something other than conventional designs, rooms, and areas. A considerable opportunity for research exists in the planning phase alone.

Materials vary in cost according to the kind, grade, and quality for various uses in dwellings. If low cost is to be achieved, designers must accept lower grades, locally available materials, partially processed lumber, or various substitutes for traditional materials. An unlimited number of examples of the use of low-cost materials may be found: Short-length flooring, end-matched pine, short-length framing, small sawmill lumber, ungraded sand and gravel, field stone, hand-split shingles, logs, adobes, low-grade interior paneling, standard cabinet units, and many other items. If the designs incorporate fire safety, durable finishes, adequate framing, masonry foundation, and weather-resistant roofs, the construction may be made adequate with relatively low-quality materials.

A reduction also in the quality of workmanship must be made to effect a decrease in housing cost. Labor normally constitutes about two-fifths of the total cost of construction (ranging from 33 to 50 per cent). There is ample evidence that the bulk of the labor on low-cost houses can

be done by unskilled or semi-skilled workmen at relatively low wages. A skilled craftsman is necessary for layout, supervision, planning, and finishing. On the other hand, common labor can do much of the hauling, excavating, concrete mixing, sawing, nailing, painting, roofing, and similar operations.

Although the plan could not be carried out in some areas, it is usually possible to obtain rural workers at wages satisfactory to them, for strictly rural construction. Farmer-carpenters, part-time farmers, and semi-skilled workmen are often available in localities where full-time skilled workers could not be secured. In the final solution, it appears that the labor for the construction of low-cost housing must be drawn from about the same economic scale, or the same wage-earning capacity as the occupants to be served.

An extremely effective method of cash cost reduction is the contribution of goods and services by the farm owner, as a substitute for the expenditure of funds. In many areas it is possible for the family to obtain and deliver sand, gravel, stone, and logs, and exchange labor and barter farm products for materials. Most farmers have sufficient skill and ability to handle a considerable part of the construction work, and the method offers an opportunity to create a capital investment in housing from the resources of the farm. The results of utilizing noncash resources are (1) the useful employment of farm labor and materials otherwise of little value, (2) the acquisition of a higher quality of housing than would otherwise be possible, (3) building is stimulated in cases where normal cash outlays would be prohibitive, (4) a considerable proportion of the cash resources is used for the purchase of manufactured goods and skilled labor, probably resulting in a greater volume of business for dealers and workmen than would be possible by any other method of procedure.

CASH OUTLAY HALVED BY FARM CONTRIBUTION OF LABOR AND MATERIALS

The basic survey work on this subject at the Arkansas station is discussed more fully in Bulletin 364[5]. In 200 cases studied, the house value was calculated at $1,575 per house. Of this value, the cash expense was $700, consisting of $176 for labor and $524 for materials; and the home contribution was valued at $344 for home labor, and $531 for materials, supervision, exchange, or other services. The experiment station has been able to build houses for less than $1.50 per square foot for all costs, without plumbing, electricity, and insulation; and less than $2.00 per square foot including these facilities, all of "good" construction. The principal saving has been in the use of a large proportion of common and semiskilled labor, native material framing and sheathing, and local sand, gravel, and stone. An estimated saving of about 30 per cent has been made by these methods.

The study of rural housing in Arkansas indicated that farmers who effected maximum practical cost reduction spent in cash about the equivalent of one year's gross income. At the higher cost levels, from one and one-half to two and one-half year's income may be required as a capital investment in housing. It is evident that this expenditure for housing will normally require financing. For this type of investment, first mortgage security or its equivalent is generally required. Under present conditions, building and loan associations lend very little for farm construction. The Federal Housing Administration plan, although authorized for farm loans, is actually used very little for this purpose. The Federal Land Bank and comparable lending agencies may lend for structural improvements and take first mortgage security. About one-half of all farms, however, are already pledged as debt security in some manner. Moreover, farmers logically hesitate to mortgage a farm that is free from debt for the amount necessary to finance a home.

In some respects, the farm security plan of lending is highly commendable. Loans are made and amortized at a low rate of interest over a long period, approximately $43 per year per $1000 to cover interest and principal payments over a 40-year period. The Farm Security Administration program, however, is restricted to a comparatively few clients, mostly in the rural rehabilitation and tenant-purchase classifications. The most pressing need in rural housing is a financing plan, for loans that do not necessitate a first mortgage on the entire farm, designed for housing only, and approximating the F.S.A. type of loan. Through some such plan, a loan of $3,000 would cost the borrower only $129 per year. If taxes, insurance and normal repairs are added, the cost to the farmer for adequate housing would approximate $180 per year, or $15 per month, at the $3,000 level; and proportionately less for smaller investments.

SUMMARY

Low-cost housing, to meet rural needs, must be (1) fitted to the economic level, within cost ranges of from $500 to $2,500; (2) restricted in size, quality, and equipment to the farmers' ability to pay; (3) represent adequate planning, low-cost labor and lower grades of materials; (4) include some home contribution of goods and services; and (5) financed by some plan that is within the capacity of the low-income family.

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Farm Buildings and Operating Efficiency

THE type of farming has greater influence in building requirement than has the size of the farm.

Each type of farming has more or less exacting building requirements in regard to the size and type of structures. For instance, milk ordinances affect the type of structures on the dairy farms. Apple and peach grading, washing, drying, and storing have exacting structural and equipment demands.

In the development of suitable building programs for these farms the type of farming and the requirements of the principal enterprises were given first consideration. Convenience, economy, durability and the appearance of the structures were other considerations. Farm service buildings are usually grouped around the barn which serves as the principal structure. — *From "Farm Operating Efficiency Investigations in Virginia, 1931-1938" (progress report) ACE-29.*

NEWS

Annual Meeting Program in Outline

AN innovation of this year's annual meeting of the American Society of Agricultural Engineers, to be held at Pennsylvania State College, June 17 to 20, is the scheduling of general and technical division sessions beginning with the first day. The College Division sessions, which in recent years have been held on the first day, have been shifted to make them the concluding feature of the meeting.

Preliminary events start Sunday, June 16, with the arrival of members and guests, and their reception and registration beginning at 2:00 p.m. The Council will hold a Sunday afternoon meeting; there will be a buffet supper and community singing at 6:00 p.m., and entertainment in the evening.

General Sessions

L. F. Livingston, chairman of the Meetings Committee, announces that short general sessions have been scheduled for Monday and Wednesday afternoons. Dr. R. D. Hetzel, president of Pennsylvania State College, and R. U. Blasingame will offer welcoming remarks, and K. J. T. Ekblaw will deliver the president's annual address Monday afternoon.

"Agricultural Engineers and Farm Chemurgy" will be the subject of an address by Wheeler McMillen, editor-in-chief, Farm Journal and Farmer's Wife, and president of National Farm Chemurgic Council, at one of the general sessions. Another general session feature will be an address by Dr. John Lee Coulter, consulting economist, on "Some Economic Aspects of Farm Machinery."

Power and Machinery

"New and Special Farm Machine Developments in the Northeastern United States" is the general topic for the opening session of the Power and Machinery Division, Monday forenoon, June 17. Eight contributions from as many states have been scheduled as follows: Pennsylvania—"Potato Growing Machinery" by E. L. Nixon; West Virginia—"A New Cotton Picking Machine" by R. H. Gist; New York—"A Rebuilt Grain Drill for Better Fertilizer Placement" by B. A. Jennings; Massachusetts—"Machinery in Cranberry Production" by C. I. Gunness; Delaware—"New Developments in Drying Grasses" by R. M. Ramp; New Jersey—"Old and New Machines in New Jersey" by E. R. Gross; Maryland—"Machinery for Stone Removal" by R. W. Carpenter; and New Hampshire—"New Equipment Developed by Farmers" by W. T. Ackerman.

In a farm chemurgic session Tuesday forenoon, June 18, the Division will hear papers on "Agricultural Engineering Aspects of Castor Bean Production" by Harry Miller; "The Role of the Agricultural Engineer in the Production of Essential Oils" by Dr. Paul J. Kolachov; "The Processing of Corn and Wheat" by J. H. Schollenberger, and one other paper on some interesting phase of farm chemurgy.

Design will be the major interest of the third session of the Division Wednesday forenoon, June 19. Papers scheduled include "Flow Lines in Forgings for Farm Machines" by J. Roberts; "The Role of Nickel in the Production of Farm Tools" by H. L. Geiger; "A Critical Appreciation of American Farm Machinery Design" by Wilhelm Vutz; and a "Report on the A.S.A.E.-Sponsored Transport Wheel Research Project" by J. B. Davidson.

Rural Electrification

The technology of using electricity in dairying will be featured in the opening program of the Rural Electric Division. Presentations will include "Results of Milk Cooling Investigations" by J. Roberts; "The Lighting of Dairy Barns" by M. A. R. Kelly and A. V. Krewatch; and "Effects of Short-Wave Irradiation on Farm Animals" by T. E. Hienton.

Papers at the second session, Tuesday forenoon, June 18, will be "Adapting Ventilating Fans to Farm Buildings" by H. N. Stapleton; "Thermostats for Agricultural Applications" by R. D. Ketner; and "Rural Line Operation in the Southeast" by L. C. Flournoy.

For the Wednesday session there will be papers on "Low-Cost Kitchen Equipment" by F. M. Wigsten; "Results of Chick Brooding Studies" by L. C. Prickett; and "Results of a Study of Small Feed Mills" by J. E. Nicholas.

In addition there will be panel discussions in which rural electrification men with the utilities, agricultural colleges, and electric equipment manufacturers, will give their viewpoints, on successive days, on how the other two groups can help them.

Farm Structures

Significant accomplishments and trends in farm structures is the opening general topic slated for this division on Monday morning. Contributions are to include "Progress in Formulating Construction Standards and Specifications for Farm Buildings" by G. B. Hanson; "Engineering Problems in Prefabricated Structural Farm Equipment" by D. H. Malcom; "Progress Report on the A.S.T.M. Fence Testing Project" by J. W. Crofoot; "Conditions for Grain Storage in the Eastern States" by G. J. Burkhardt; "Temporary Silos for Grass Silage" by H. C. Smith; "Results of Laboratory Studies of Sawdust Concrete" by L. W. Newbauer; "How Much Should Farm Buildings Cost?" by H. B. White; and "How the Farm Structures Division Can Function More Effectively" by R. H. Driftmier.

"Standardization of Sanitary Milk Codes and Ordinances Affecting the Design of Dairy Structures" is the title of a symposium to be held Tuesday forenoon, June 18. A. W. Fuchs, senior sanitary engineer, U. S. Public Health Service, and Donnell Marshall, manager, Laurel Locks Farm, will present the subject from the standpoints of consumer and producer interest, respectively. Their presentations will be discussed by S. A. Witzel and J. D. Long.

For the Wednesday morning session, papers scheduled include "Ventilation of Animal Shelters" by A. M. Goodman; "A Rational Approach to Poultry House Design" by J. L. Strahan; "The Place of Farm Buildings in the Land-Use Program" by Gladwin Young, regional representative, U. S. Bureau of Agricultural Economics; and "A Philosophy of Farm Structures" by E. E. Brackett.

Soil and Water Conservation

The program of this division will give major attention to the basic science and engineering data involved. Papers of this nature are to include "A New Method for Determining an Index of Supplemental Irrigation Based on Rainfall" by F. E. Staebner; "A Graphic Presentation of Land-Use and Hydrologic Data" by C. S. Jarvis and H. C. Murto; "The Effect of Rain-drop Size Upon Erosion and Infiltration" by J. Otis Laws; "Developments in Runoff Investigations in the Northeast Region" by Harold W. Hobbs; "Soil and Water Conservation Problems in the Northeastern States" by Dr. John J. Jones; and "A Graphical Method for Direct Determination of Channel Dimensions Required for Selected Velocity and Discharge Capacity, with various Gradients and Roughness Conditions" by R. B. Hickok.

Along this same line, there will be reports of the Committee on Reservoirs and Ponds, Committee on Hydrology, and Subcommittee on Contour Furrowing.

In addition there will be a paper on "Terrace Maintenance" by C. L. Hamilton, and subjects still tentative include "Terrace Outlets of Corrugated Metal," "Principles of Tile Drainage," and "New Developments in Equipment for Supplemental Irrigation."

College Division

At time of going to press the College Division program had not been reported in detail, but it is expected that it will include a combined session, followed by separate sessions of the student, research, teaching, and extension groups.

Entertainment and Other Features

Time for committee and other group meetings has been left open afternoons, outside of that scheduled for general sessions and other activities for the whole group.

The annual business meeting of the Society is to be held Wednesday afternoon at 4:00.

Wednesday evening, at 7:00 o'clock, the annual dinner of the Society will be held at the Nittany Lion Hotel. It will feature awards of the F.E.I. Student Branch Trophy, and of the John Deere and Cyrus Hall McCormick Gold Medals; and inauguration of E. E. Brackett as the new President of the Society. Entertainment will follow, at 9:30.

In addition to the entertainment features already indicated, there will be "Coffee Hour" at 8:00 p.m. Monday; inspection trips Tuesday afternoon, a picnic at 6:00 p.m. Tuesday, and entertainment at 8:00 p.m. that evening; and special activities for ladies and children at other times.

(News continued on page 194)

A.S.A.E. Meetings Calendar

June 17-20, 1940—Annual Meeting, State College, Pa.

August (last week, tentative)—North Atlantic Section, Orono, Me.

December 2-6, 1940—Fall Meeting, Chicago, Ill.

Personals

E. L. Barger and *John M. Ferguson* give suggestions on construction of "Tractor Lighting Equipment" in Kansas State College, Extension M Circular 22 (February 1940).

Harold H. Beaty has written "Electric Wiring for Farm Buildings," Iowa Agricultural Extension Circular 257.

H. J. Gallagher has compiled a "Report (of the Consumers Power Company) on Farm Service, Year 1939, and Review of Progress from 1930 to 1939, Inclusive."

M. A. R. Kelley is the writer of U.S.D.A. Farmers Bulletin No. 1832, on "Farm Fences."

W. C. Krueger is one of the authors of "Surface Swamping and its Treatment," New Jersey Agricultural Extension Bulletin 215.

Lloyd T. Petersen is now associated with United Specialties Company, United Air Cleaner Division, Chicago, Ill., in charge of the experimental laboratory and new developments. He was formerly designing engineer for Hardie Manufacturing Co.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the April issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Newton O. Belt, consulting engineer, 1600 Washington St., Wilmington, Del.

Everett H. Davis, extension agricultural engineer, Oregon State College, Corvallis, Ore. (Mail) 231 N. 30th St.

William A. Davis, area engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) P. O. Box 67, Yerington, Nev.

Murray E. Dodds, instrument man, Dominion Experimental Station, Swift Current, Sask., Canada.

W. Berkeley Grizzard, assistant, agricultural engineering department, Purdue University, Lafayette, Ind. (Mail) Box 603.

Harold E. Gray, North Stonington, Conn.

Paul Huey, western manager, Progressive Farmer-Ruralist Co., 2050 Daily News Bldg., Chicago, Ill.

Milton R. Langer, designer, Franklin Equipment Co., Monticello, Iowa.

Ben Ouchi, student, Finlay Engineering College, Kansas City, Mo.

A. Stephen Paydon, R.R. No. 1, Plainfield, Ill.

Carl E. Peterson, project engineer, Soil Conservation Service, U. S. Department of Agriculture. (Mail) 15 North Cherry Ave., Freeport, Ill.

Kirk M. Sandals, assistant hydraulic engineer, Bureau of Agricultural Economics, U. S. Department of Agriculture. (Mail) Room 410, Terminal Bldg., Lincoln, Nebr.

L. E. Sinclair, farmer, Box 234, Calipatria, California.

TRANSFER OF GRADE

C. H. Jefferson, assistant professor, Michigan State College, East Lansing, Mich. (Mail) 236 Oakhill (Junior to Member)

Student Branch News

MISSOURI

THE University of Missouri Student Branch of the A.S.A.E. has been holding regular meetings every two weeks. At these meetings, talks and motion pictures have been featured. Other activities of the Branch include a dance given March 29 at the new Student Union Building, and an exhibit at the annual St. Pat's Celebration and Exhibition.

Charles Worstell received the Engineering Foundation Award for the highest scholastic ranking of the juniors enrolled in agricultural engineering. Prof. M. M. Jones and George Steinbruegge were recently pledged to Tau Beta Pi, national engineering honorary fraternity.

Copies of the annual Missouri "Ag Engineer" are off the press and are now being distributed.—*Charles Worstell, publicity.*

OHIO

GLENN W. McCUEN and Virgil J. Overholt were honored for being with the department for twenty-five years, by the Ohio Student Branch of The American Society of Agricultural Engineers at their spring banquet Thursday evening, April 25.

Both professors have been with the agricultural engineering department for twenty-five years, and Mr. McCuen has been chairman of the department for sixteen years.

The talk of the evening was delivered by Alfred Vivian, Dean Emeritus of the College of Agriculture. He talked of the growth of Ohio State University, of the College of Agriculture, and of the agricultural engineering department in particular. He commented on the excellent work done by both Professor McCuen and Professor Overholt, and said, "They are both men whose scientific ideals are high."

Mr. McCuen graduated from the University of Illinois in 1915 and came to Ohio State University the same year. He was instructor for two years, assistant professor for three years, and has been a full rank professor for twenty years. He has been chairman of the agricultural engineering department since 1924, and has seen the faculty force grow from four to twelve in number. He was president of the American Society of Agricultural Engineers for the year 1934-35, and its delegate to the International Congress of Agricultural Engineering at Madrid, Spain, in September, 1935. He was president of Gamma Sigma Delta, agricultural honorary, in 1937 and 1938, and is now president of the Alpha Zeta Alumni Group. He is a member of Acacia, Sigma Xi, Gamma Sigma Delta, and an honorary member of Alpha Zeta.

Mr. Overholt graduated from Ohio State University in 1915, and immediately began working in agricultural engineering extension. He was the first agricultural engineering extension specialist in Ohio, and one of the first in the United States. During the first twelve years after graduation, he was a full time agricultural extension specialist, and since that time his work has been divided between teaching and extension. The Smith-Lever Act, creating extension service, was only one year old when Mr. Overholt began with agricultural engineering extension. He has been a full rank professor for ten years. Mr. Overholt has been a full member of the American Society of Agricultural Engineers since 1917, and was chairman of its Soil and Water Conservation Division for the year 1937-38. He is a member of Gamma Sigma Delta, honorary agricultural fraternity.

Installation of officers also took place at the banquet, and the outgoing officers were honored. Outgoing officers were: Robert E. Hartsock, president; Harris M. Gitlin, vice-president; Edwin L. Miller, secretary-treasurer; Edward Austin Spetka, sergeant; and Glenn Yoder, senior representative to Engineer's Council. The new officers are as follows: Edwin L. Miller, president; Robert L. Erwin, vice-president; David E. Parr, secretary-treasurer; Arthur L. Gregg, sergeant; and Harold L. Geiger, junior representative to the Engineer's Council. The faculty adviser of the group is Richard C. Miller.

Music for the banquet was provided by Charles Payne, who played several numbers on his accordion. The master of ceremonies was Cecil H. Robinson, past president of the Branch.

On this occasion it was announced that the Branch would have a mixed picnic on May 17.—*David E. Parr, Secretary.*

NORTH CAROLINA

AT a recent meeting of the North Carolina Student Branch of A.S.A.E. the following officers were elected to serve through the spring term: William Huggins, president; L. B. Altmon, Jr., vice-president; Woodly Warrick, secretary; Leon Hunnings, treasurer; and Bruce Carawon, reporter. Charles Lockheart was appointed chairman of the program committee by the new president.

Several members are planning to attend the A.S.A.E. annual meeting at State College, Pennsylvania, June 17-20. The Branch is working on various projects to raise money to send a group of students to the meeting. We are building hog feeders, hog waterers, picture frames, and making concrete house numbers.

Increasing interest and activity is noticeable in the Branch. It won second place in a recent stunt night program held by the Ag Club.

Louis Trevathon, Charles Lockheart, and Woodly Warrick gave a broadcast over station WPTF on "Uses of Electricity on the Farm" on April 9. Many good comments were received on the program.

Joe B. Richardson, a new member of the faculty, talked to the Branch on April 10, on "How to Get a Job," of particular interest to the seniors who graduate this spring.

The project of the year for the Branch is to collect and compile data concerning the agricultural engineering departments in the universities in the United States. The work on this book is going along nicely and much valuable information is being collected.

During the last business meeting the members voted to accept the model constitution provided by the A.S.A.E. This constitution was practically the same as the one drawn up and adopted by the charter members of the branch.

Plans are under way to initiate several new members during the fall term of 1940. —*Bruce Carawon, Reporter.*

Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, assistant chief, Office of Experiment Stations, U. S. Department of Agriculture. Copies of publications reviewed may be procured only from the publishers thereof, whose names and addresses may be obtained on request to AGRICULTURAL ENGINEERING, St. Joseph, Michigan

CURING TEMPERATURE IN RELATION TO STORAGE QUALITY OF THREE VARIETIES OF SWEET POTATOES, *H. B. Cordner*. (Okla. A. and M. Col.) Amer. Soc. Hort. Sci. Proc. 35 (1938), pp. 569-571. Roots of Nancy Hall sweetpotatoes shrank least in storage and kept satisfactorily following curing at as low as 70 F. Porto Rico roots kept best after curing at 92 F, with slightly greater storage losses following curing at 80 F. The greatest storage losses were found in roots of the Maryland Golden, where it seemed imperative that a high curing temperature, about 90 F, be used. Some attention evidently should be paid to relative humidity in the storage environment to avoid shriveling of roots of Maryland Golden.

INFLUENCE OF RAINFALL, CROPPING, AND CULTURAL METHODS ON SOIL AND WATER LOSSES, *R. P. Bartholomew, D. G. Carter, W. G. Hulburt, and L. C. Kapp*. Arkansas Sta. Bul. 380 (1939), pp. 48, figs. 10. At the main station and at the fruit and truck substation erosion studies were carried out on 6 per cent and on 2.9 per cent slopes, respectively, and at both stations both on normal soil and on badly eroded soil from which 6 in of topsoil had been removed. Continuous cropping, rotation, permanent Bermuda grass cover, and fallow with weeds scraped off the surface were tried at both stations. Both total rainfall and very short period intensity records were kept. The work covered the period from May 1, 1935, to June 30, 1938. The numerous observations and detailed data presented include the following:

The data indicate that the moisture condition of the soil is a factor, since runoff losses were much higher when the soil was saturated or nearly so. Well established Bermuda sod reduced losses to less than 0.3 per cent of the total rainfall recorded during the experiments. In a 3-yr rotation protection was afforded by ground cover for all except from 5 to 6 mo. Within the rotation, clover was most effective, oats somewhat less effective, and the largest losses occurred while the plats were in corn. The use of rotation tends to increase the ability of the soil to take up water. The increase in permeability of the soil as a result of plowing results in a decrease in runoff. A winter-plowed plat showed no appreciable runoff from January to March 25, 1938, although there were in that time 13 rains which caused runoff from fallow unplowed ground. April plowing on other plats resulted in decreased losses for a limited time. The addition of organic matter by plowing under the crop residue resulted in decreased losses. The eroding of the surface layer tends to accelerate runoff losses. During 2 yr of record, the runoff loss from the plat from which 6 in of surface soil had been removed exceeded that of any other cultivated plat. Soil losses are closely related to runoff losses.

EFFECT OF SOIL TYPE, SLOPE, AND SURFACE CONDITIONS ON INTAKE OF WATER, *F. L. Duley and L. L. Kelly*. (Coop. U. S. D. A.) Nebraska Sta. Res. Bul. 112 (1939), pp. 16, figs. 5. The authors sprinkled 0.005-acre plats of various soils from an overhead oscillating sprinkling device with fan-shaped nozzles. A constant water head was maintained by pumping from a large supply tank into a smaller, elevated, constant-level tank. The rate of application was determined by a special water meter, and the runoff was measured in a two-compartment tank calibrated to 0.001 in of runoff from the plat area. The time required for a given runoff to take place was read on a stop watch. From these data rate curves for both runoff and infiltration were obtained.

The rate of intake of water at the beginning of application was often very high, decreasing rapidly at first, and finally reaching an approximately constant infiltration rate. The total intake of water and also the final infiltration rates on cultivated bare land showed much less variation among the different soil types than was anticipated. The soils tested varied greatly in the texture of the surface soil and in profile characteristics, but the quantity of water taken in during a given time was strikingly similar for all soils, and the infiltration rates were finally reduced almost to a common level. Even sandy soils closed up until infiltration was very slow.

The total intake and the infiltration rate decreased slightly with increase in slope. However, this change in infiltration rate was found very small and very gradual with changes in slope above about 2 per cent.

There seemed to be no consistent or significant difference in the rate of infiltration due to difference in the rate of application of water when the rate of application materially exceeded the rate of intake. With continuous application of water the rate of infiltration gradually decreased to a point where it became nearly, but not absolutely, constant. A plat which received water and was then allowed to stand for a short time showed a sharp decrease in the infiltration rate. However, upon standing for several days or a week and then receiving another application the infiltration rate approached a constant usually higher than that at the end of the previous application period. This rate was again reduced after the plat had again stood in a wet condition.

Soils covered with a crop showed a much higher rate of intake of water than bare soils and maintained this higher infiltration rate throughout extended tests. The denser crops like native sod and alfalfa showed the highest and the longest maintained infiltration rates. Sod land with grass clipped close and surface debris removed showed a rate only a little above that of bare cultivated soil. Soil covered with crop residue such as straw or other organic material gave an infiltration rate similar to or possibly higher than that obtained when the soil was protected by a dense growing crop. The total intake of water when the soil was thus protected was very great on all the soil types tested, and the high rate of intake was maintained over an extended period. In fact, it was sufficient to take care of an amount of water greater than that likely to be received during any rainfall period in Nebraska. Claypan soils (Pawnee clay loam and Butler silty clay loam) absorbed large quantities of water within a short period of time whenever the surface was protected by means of a straw mulch.

"There may be far greater variation between the rates obtained under different surface conditions on a single soil than would be shown by different soils having the same surface conditions. This may make it necessary to think of infiltration rates characteristic of surface conditions rather than of different soils. . . .

"The breaking down of soil structure, by the compacting effect of the rain and the assorting and rearranging of the soil particles by running water forming a compacted layer at the immediate surface, appears to be the principal reason for the low infiltration rates on cultivated land. The formation of this semipervious layer, often only a few millimeters thick, was largely prevented by a covering of straw or by a growing crop."

DRYING AND CURING OF BRIGHT LEAF TOBACCO BY MEANS OF CONDITIONED AIR, *A. H. Cooper, C. D. Delamar, and H. B. Smith*. Va. Polytech. Inst. Bul. 32 (1939), No. 6, pp. 28, figs. 8. In the experimental application of air conditioning to the curing and drying of tobacco, drying rate curves for each period of the curing process were obtained over a wide range of constant conditions of temperature, humidity, and air velocity. Correlation of the curing curves indicated narrow limits of conditions for satisfactory curing and critical points beyond which poor quality of tobacco results. "From the results obtained, air conditioning improves the process by (1) reducing the time approximately by one-half, doubling the capacity of the barn; (2) production of uniform quality tobacco, completely eliminating loss from improper curing; and (3) considerable reduction in labor and fuel requirements." Another suggested advantage is reduction of fire hazard.

FARM STORAGES FOR NEW ENGLAND APPLES, *C. I. Gunness, W. R. Cole, and O. C. Roberts*. Mass. Sta. Bul. 360 (1939), pp. 32, figs. 16. Devoted for the most part to providing general information on the design and structure of storage buildings, refrigeration equipment and operation, management of storage houses, physiology and handling of fruit, temperature and relative humidity control, etc., this bulletin presents certain research results. McIntosh apples held at 45 F during the 10-day harvesting period, and for 5 days later, developed their maximum quality; but when fruit was to be kept later than January 1, it was necessary to place it immediately in 32 F storage. Although a high relative humidity (about 85 per cent) is desirable, experiments showed that lower relative humidity during harvesting and storing is not essentially harmful. *(Continued on page 198)*

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PLACEMENT OF FERTILIZER FOR SPINACH, KALE, AND COLLARDS, *M. M. Parker, R. C. Oliver, G. A. Cumings, W. H. Redit, and L. G. Schoenleber.* (Coop. U. S. D. A.) Virginia Truck Sta. Bul. 101 (1938), pp. 1595-1618, figs. 5. In studies extending over several years and conducted on three soil types—Sassafras sandy, Elkton silt, and Norfolk sandy loams—it was found that fertilizers placed in narrow bands on the sides of the seed row and below the level of the seed invigorated the germination of collards, kale, and spinach seed regardless of the soil moisture supply. Fertilizers placed in a narrow band directly below the seed were injurious, especially when the soil moisture was relatively low. Fertilizers broadcast several weeks in advance of or immediately prior to planting had very little effect on germination. Those mixed in the row just before planting kale and collards were toxic when moisture was inadequate. The amount of injury to seed germination with unfavorable placements was associated closely with the amount of rainfall directly preceding and following seeding. In the case of less fertile soils, fertilization following germination resulted in a period of comparatively slow growth. The largest yields of spinach and kale were obtained by side placement of fertilizer, while with collards slightly better results followed placement in a narrow band 3 in directly below the seed.

CONTOUR PLANTING AND TERRACING AS A BASIS FOR SOIL AND WATER CONSERVATION IN ORCHARDS, *J. T. Bregger.* (U.S.D.A.) Amer. Soc. Hort. Sci. Proc. 35 (1938), pp. 7-12. Tracing the history of contour planting of orchards, the author discusses types of orchard terraces, auxiliary erosion control practices (such as cover cropping and mulching), and effect of contour planting, and points out needed research. Four years' records obtained in a 25 per cent slope vineyard at Hammondsport, N. Y., showed material increase in yield and decrease in water and soil losses on the contour plan as compared with up-and-down cultivation.

COST AND UTILIZATION OF POWER AND LABOR ON IOWA FARMS, *W. D. Goodsell.* Iowa Sta. Res. Bul. 258 (1939), pp. 317-363, figs. 10. This study is based upon the actual experiences of 1,961 farmers as shown by 869 farm management association records, 842 nonassociation records, 425 tractor and 125 horse records, and approximately 250 farm survey records kept or obtained in 1936 and 1937. The types of power on the cooperating farms are described. Analysis is made of the costs of operation of horses, tractors, and trucks; the horse, machinery, tractor, and man-labor costs on horse, standard tractor, and general-purpose tractor farms; and the performance of tractors and horses in farm work. A comparison is made of the organization and management of farms of similar size and having similar amounts of livestock but operated with different types of power, including discussion of the effect on costs of length of time a given type of power has been used, the influence of type of power on land use and crop yields, and the sources of income on farms operated with different types of power.

The general-purpose tractor farms were considerably larger than the standard tractor farms, which were larger than the horse farms. The average hours of horse work per farm were 814 in 1936 and 802 in 1937, and the average costs per hour were 11.2 cents and 10.7 cents. The average number of hours varied from 680 on farms with approximately 75 acres in crops to 854 on farms with about 375 acres in crops. Feed costs per horse varied from \$56 to \$71. The amounts of roughage fed did not differ with size of farm or hours worked. The pounds of grain fed per horse varied from 2,050 on the smaller to 4,518 on the larger farms, due to the larger number of hours the horses were worked. Operating costs per hour and horsepower-hour for different types and sizes of tractors were: General-purpose one-plow 54 cents and 5.5 cents, general-purpose two-plow 52 cents and 4.7 cents, general-purpose three-plow 60 cents and 5.2 cents, standard two-plow 63 cents and 4.9 cents, and standard three-plow 70 cents and 4.4 cents. Tractors on pneumatic tires used 22 per cent less fuel and had an estimated life 34 per cent longer than steel-wheeled tractors, but these economies were offset by tire costs. The average yearly mileage and costs of operation per mile for farm trucks were: 1½-ton 3,024, and 6.3 cents, 1-ton 3,660 and 5.1 cents, and ½-ton 5,441 and 3.9 cents.

Labor costs per acre were slightly higher on horse farms than on tractor farms of comparable size, but there was no consistent difference in the combined costs for labor, horses, tractors, and machinery on general-purpose tractor and horse farms. Those on standard tractor farms were higher. On general-purpose tractor farms 4.9 hours of man labor and 27.46 drawbar horsepower hours, and on horse-operated farms 9.4 hours of labor and 30.88 drawbar horsepower hours, were used per acre of corn up to harvest. Managerial ability of the farm operator was the most important factor in power costs. *(Continued on page 200)*

NEW McCormick-Deering 4-FOOT COMBINE

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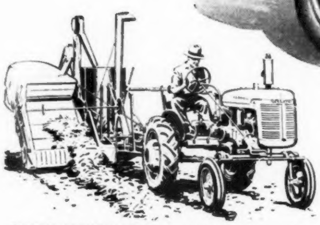

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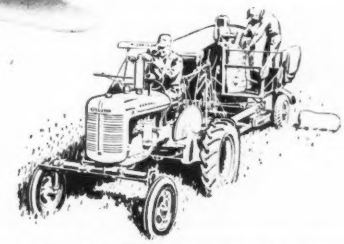

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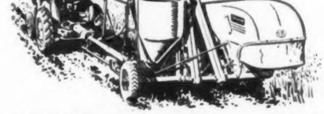

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(Continued from page 198)

EFFECT OF ARTIFICIAL DRYING UPON THE GERMINATION OF SEED CORN, *T. A. Kiesselbach.* (Nebr. Expt. Sta.) Jour. Amer. Soc. Agron., 31 (1939), No. 6, pp. 489-496. Drying experiments with seed corn, 1937 and 1938, involving procedure similar to that of Harrison and Wright showed an apparent inverse relation between drying temperature and minimum moisture content attained by the dried seed. After 5 days of drying at 112 F the moisture approximated 5 per cent, while at 107 F it was about 6.5 per cent. It seemed that little further desiccation would occur from prolonged exposure at these temperatures. Seed with initial moisture content up to 30 per cent and reduced to as low as 5 per cent by drying for 5 days at 112 F showed no unfavorable effects on field stand or seedling growth. When dried at 112 F no significant differential injury appeared among 26 representative hybrids ranging from 16 to 38 per cent in moisture content.

Timely and suitable drying of seed corn with heated air under forced draft may remove the freezing injury hazard, facilitate early harvest, storage, and processing, and avoid injury to seed viability or field performance. With such artificial drying, reduction in moisture content to from 12 to 13 per cent at a range of from 105 to 110 F is recommended except that temperature be held as low as 105 F when the initial moisture content approaches 50 per cent. Prolonged drying at safe temperatures to as low as 5 per cent moisture is not harmful, although not practical. Insufficient drying subjects the seed to later loss of weight and possible deterioration in storage. The moisture content permissible for safe processing and storage ranges from 5 to 14 per cent. The drying period needed to reduce ear corn to a safe moisture content varies with the initial moisture content of grain and drying temperature, approximately 1, 2, or 3 days for corn containing 20, 30, and 50 per cent moisture, respectively, provided the air is changed enough.

EFFECT OF TEMPERATURE ON THE RATE OF DETERIORATION OF FRESH VEGETABLES, *H. Blatenius.* (N. Y. [Cornell] Expt. Sta.) Jour. Agr. Res. [U. S.] 59 (1939), No.1, pp. 41-58, figs. 8. The rate of deterioration of seven kinds of fresh vegetables was determined for temperatures ranging from 35 to 80 F. When plotted against the temperature, the calculated temperature coefficients followed a logarithmic curve with a break between 50 and 65F. Q_{10} values expressing the rate of deterioration varied not only with different kinds of vegetables but also with different temperature ranges—the highest values always being found at relatively low temperatures. Temporary storage at 35 F had no appreciable effect on the subsequent rate of break-down after transfer to higher temperatures. Different temperature coefficients and Q_{10} values were found to depend on whether the rate of deterioration was measured by visible break-down or by the rate at which sugar depletion occurs in these vegetables. Based on the rate of sugar losses, peas had a Q_{10} value of 27.5 at relatively low temperatures and 1.4 in the upper temperature range.

Literature Received

WHY ANTI-FRICTION BEARINGS. Paper bound, 112 pages, 5½x8½ in, illustrated, indexed. A discussion of the development and merits of rolling or anti-friction bearings, for use as a supplementary text for engineering students and as a reference on the subject of bearings and bearing friction for all engineers who meet problems in this field. New Departure Division, General Motors Sales Corporation, Bristol, Conn. Gratis.

EMPLOYMENT BULLETIN

The American Society of Agricultural Engineers conducts an employment service especially for the benefit of its members. Only Society members in good standing may insert notices under "Positions Wanted," or apply for positions under "Positions Open." Both non-members and members seeking to fill positions, for which ASAE members are qualified, are privileged to insert notices under "Positions Open," and to be referred to members listed under "Positions Wanted." Any notice in this bulletin will be inserted once and will thereafter be discontinued, unless additional insertions are requested. There is no charge for notices published in this bulletin. Requests for insertions should be addressed to ASAE, St. Joseph, Michigan.

POSITIONS WANTED

AGRICULTURAL ENGINEER with B. S. degree from South Dakota State College (1936) and a farm background, desires employment with machinery company, large construction company, or any branch of agricultural engineering extension work. Has four years of experience as construction engineer with the land utilization division of Soil Conservation Service on a land development program. Age 26. Married. Can go to any location. Complete information furnished upon request. Best of references. PW-317